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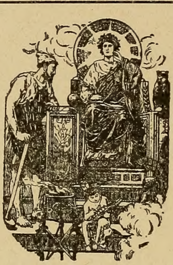

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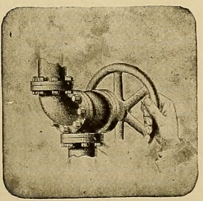

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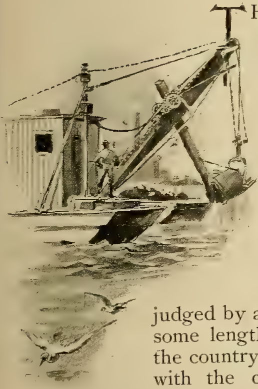
PUMP DREDGING IN HOLLAND.

By W. H. Booth, M. Am. Soc. C. E.



THE art of dredging in Holland is not one which has grown up from any desire of improvement of the rivers and harbors of the country; it has risen from the absolute necessities of the people, and these cannot be judged by a stranger without some length of residence in the country to familiarize him with the conditions of life upon a land much of which is many feet below sea level.

There are five main types of underwater dredgers employed in Holland, which we may number A, B, C, D, E, as follows:

A.—Bucket dredger with mud pump.

B.—Suction dredger with mud pump.

C.—Bucket dredger discharging into independent vessel carrying mud pump.

D.—Suction hopper dredger.

E.—Bucket hopper dredger.

Each of these different types has its special applications, and the choice of one or the other must be governed by a consideration of such conditions as apply in each case. Though type A is perhaps the earliest form of pump dredger, it may be well to briefly note first some of the types which have been evolved from it. Pump dredging differs from ordinary dredging in the fact that the dredged material is either directly removed from its bed by means of a current of water flowing to a centrifugal pump, or it is dealt with after removal by being passed through such a pump and forced to some distant point in a state of more or less liquidity, sufficient water being employed to act as a carrier of the solid particles, which are mixed with the water either by the pump fan itself, or, in more powerful, modern machines, by a specially arranged breaking and mixing apparatus which serves also to separate timber, stones or other materials unsuitable for discharge through the eduction pipes or the pump itself.

Commencing, then, with the last type on the list, we find in type E the familiar machine which consists of a hull of simple form, carrying amidships a standard or tower from which is suspended the bucket ladder. Dredgers of this type are made either to discharge into separate hopper vessels alongside or they are their own hoppers, in which case they are also made self-propelling. For a hopper capacity of 350 cubic yards, one of these machines will have the following dimensions:—length, 153 feet; breadth, twenty-three feet; depth,

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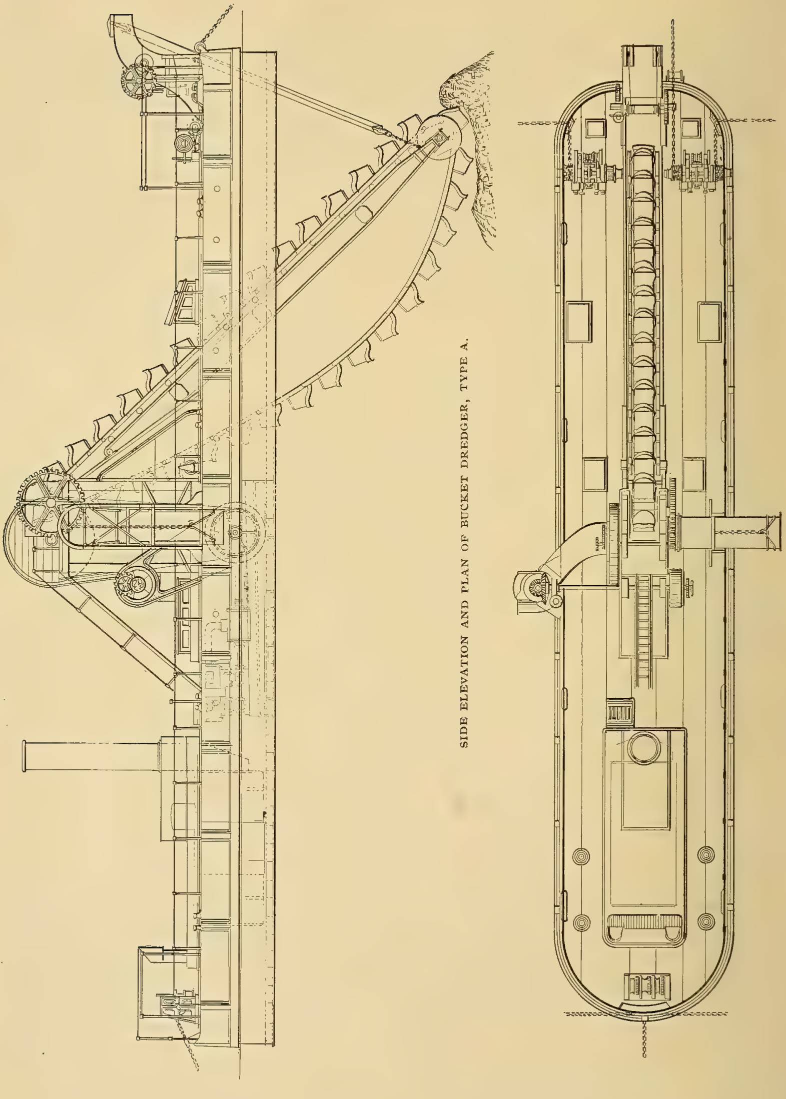


SIDE ELEVATION AND PLAN OF BUCKET DREDGER, TYPE A.

twelve feet four inches; length of ladder well, sixty-nine feet; draft, loaded, eleven feet. By lowering the upper pivots of the bucket ladder and adding links in the chain a vessel of this size may be made to dredge to a depth of thirty-three feet. Such a dredger was built by the Werf-Conrad, of Haarlem, for the Harbor of Yokohama, and was designed to steam out to Japan at a speed of 6½ knots. The engines are compound, with cylinders 20 and 32 inches by 18¾ inches stroke, indicating 320 horse-power at 130 revolutions with a boiler pressure of ninety pounds. They are connected by powerful friction cones to the screw shaft or to the dredging machinery. When dredging, they run at half speed only. Two boilers, ten feet by nine feet, are sufficient to supply steam. Such machines have advantages under certain circumstances, being entirely self-contained, capable of steaming from port to port, and carrying their own spoil to the dumping ground without a tug. The disadvantage under which they work is the stoppage of dredging operations when dumping. The rate of dredging is about fourteen buckets per minute, and the capacity, 400 to 420 yards per hour.

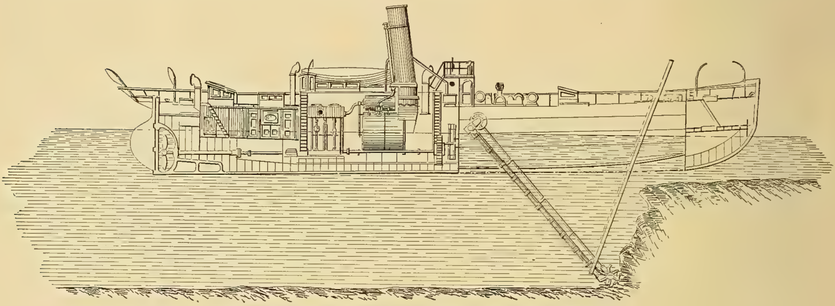
In type D we have a machine suitable for dredging pure sand. In place of a chain of buckets there is large pipe, hinged to the side of the vessel, the nose of this pipe traversing the floor to be dredged, and the inboard end terminating in a large centrifugal pump, placed transversely in the ship and discharging into the hoppers. The sand settles in these and the large surplus of water flows overboard. Such a dredger may be self-propelling or not as desired, and, of course, may discharge into independent hopper barges.

For the regulation works, near Bremen, Germany, of the river Weser, a dredger of type B was employed. It is self-propelling and will discharge spoil at a considerable distance through floating pipes. This dredger is fitted with a large centrifugal fan, upon a horizontal axis, which draws the material, mixed with a large quantity of water, up a large dredging pipe which occupies the place of the ladder in the ordinary bucket dredger. To render it capable of dealing with material other than loose sand, the nose of the draft pipe is fitted with revolving spiders to cut and break down the harder substances into loose fragments which can be drawn into the suction tube. Of this machine it may be stated that with a floating pipe about 2700 feet in length as much as 130 cubic yards of heavy quick settling sand were transferred per hour and delivered at the end of the pipe, at a height of about thirteen feet above sea level. Two hundred and ten cubic yards were similarly delivered through a pipe 1300 feet long at the same elevation. A disadvantage, however, of this machine is that the dredging is all done out of sight, and it is sometimes the case that the machine is delivering water only, it being possible for the dredging master only to guess at the work being done at the nose of the suction pipe.

The excellent results obtained nevertheless by these machines led to the design of type C, in which the just-mentioned uncertain action is avoided. The old bucket ladder is retained and the dredging is simply conducted in the ordinary manner, with the feed controlled by anchors fore and aft, and on either side, all worked from winches under the control of the master. There are two separate vessels in this system, one being a simple bucket dredger discharging spoil by a shoot on either side, while the other holds the pumping machinery only. The spoil is delivered to a hopper upon the deck of the pumping vessel, and this also receives the discharge of a centrifugal pump of a capacity of about 560 cubic feet per minute. This water washes the spoil through the gridded floor of the hopper, whence it descends below a breaker wheel direct to the discharging pump. The remainder passes forward upon the breaker wheel which further disintegrates the larger lumps and delivers all small material and mud to the discharge. The breaker wheel works close up to a weighted screen which is arranged to swing away from the wheel and allow stones and other irreducible articles to be rejected upon a grid, where they are finally washed by a water jet and removed by other means. All the pulped stuff which finds its way below the breaker wheel is drawn into the large centrifugal pump which discharges through floating pipes to the dumping ground. When the distance to the dump is more than about 1700 feet, a second, or relay pumping vessel is placed in series, and in this manner by a relay pump at intervals of say 1700 feet, spoil may be discharged to any distance, each relay pump drawing off the contents of the mud pipe, and sending it forward with renewed energy and thoroughly churned.

This type of machine was made for the Weser Regulation Works by the Werf-Conrad, of Haarlem, as an improvement upon the type B. When tested, before being taken over from the contractors, the machine, without the pumping vessel, filled fourteen barges of 200 tons capacity in eight hours. At subsequent tests, with the pumps at work and delivering through a pipe of about 1700 feet, the output per hour was 252 cubic yards of heavy sand and clay for which duty 774 pounds of coal per hour were consumed. Of this quantity, dredging proper used 152 pounds, the pump consuming 622 pounds. During another test, when care was taken that the buckets ran full of spoil, the machine dealt with about 314 cubic yards hourly for three consecutive hours, delivering all at the height of about thirteen feet. The contract was to dredge 196 cubic yards per hour and deliver through 1700 feet to a height of thirteen feet with 800 pounds of coal, the work to be done, in the open tidal river, and also in a quiet place, lifting stuff which had been deposited by hoppers from distant dredging operations. The performance thus exceeded the conditions laid down by fifty per cent.

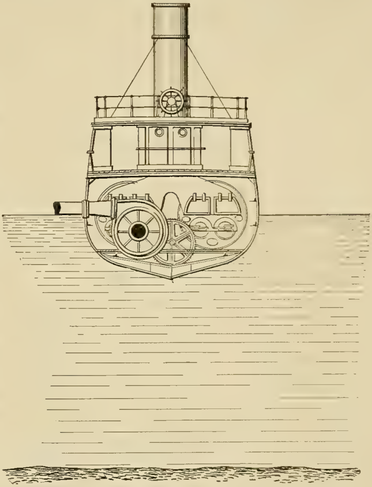
These dredgers are by no means large or cumbersome. The hull of the dredger proper is 110 feet long, twenty feet broad, and eight feet six inches deep. The buckets contain each ten and one-half cubic feet, and the maximum dredging depth is twenty-three feet. The engines indicate ninety horse-power, and are of the horizontal compound surface condensing type. The floating discharge pipes are about nineteen and one-half inches in diameter, and are jointed in lengths of about twenty feet with strong leather joint pieces encased in a kind of fine chain mail. The degree of wetness of the discharged material is best kept up to that point which will maintain a pressure gauge placed on the first length of pipe at not over two and one-fourth atmospheres, or equal to a water column of about 62.3 feet.


SECTION OF SEA-GOING PUMP DREDGER, TYPE B.

It may here be pointed out that to secure the best results in pump dredging it must be possible for the dredging master either to see the spoil as soon as dredged, as in the ordinary bucket dredge where he sees the buckets as they rise out of the water full or empty, or to see the discharge of the mud pump into a hopper or hopper barge close alongside. Hence the type B arrangement, with long floating pipe and invisible suction, is not very certain in action. The dredging master should be able to know at once if stuff is being dredged, for on this depends the output, and the best of machines cannot show good results if not fed up to the work.

The various modifications now described all have their origin in the pump dredger as first made, type A. It is not known by whom this important departure in practice was brought about. In its original form—a form still much used and which is still best for many purposes—the pumping machinery is simply an addition, on the same vessel, of a centrifugal pump to the ordinary bucket dredger. The pump is placed at the base of a vertical cylinder attached to the outside of the hull, the fan working upon a vertical shaft and being fixed so that it rotates just below the water level. The cylinder is open both above and below, the lower opening to the water being capable of regulation by a conical float valve. The upper side is open to receive the dredged material from the buckets which discharge either to the pump cylinder or by a shoot to a barge on the opposite side. The spoil is thus free to fall through the pump fan into the sea and would do so but for the motion of the fan, which breaks it up and discharges it to the floating pipes—with as much water as the pump will throw in addition to the spoil.

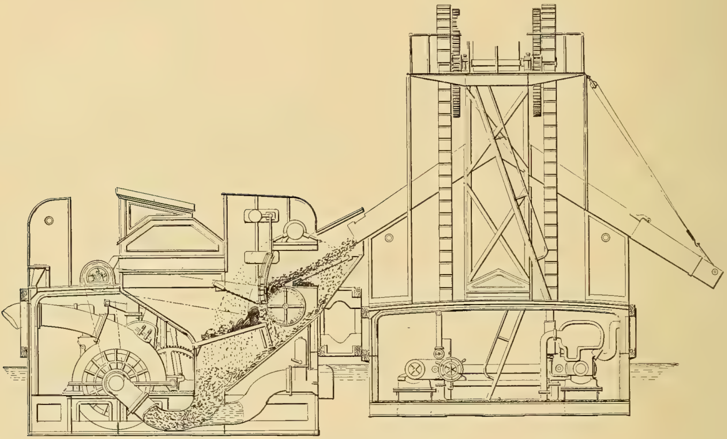
In Holland, when a piece of ground is to be raised in height, it is the practice to throw up around its border a light bank of from about three to six feet in height. Into this enclosed area is taken the discharging end of the dredger pipe, and material is lifted from the bottom of the river or channel in which the dredger lies, such material often being previously dumped from hopper barges brought from distant operations. An opening is left at the remote corner of the enclosed area from which escapes the surplus water that has deposited its load of spoil upon the land. The writer has proposed to thus construct the side banks of a canal across a low tract of land, small banks being first thrown up by hand along the lower boundaries of the proposed banks, and the material dredged from the channel being discharged between these banks, a height of about six feet being thus built up on either side of the canal in two stages of three feet each. By carrying the little banks well ahead of the point of discharge, the effluent water will deposit all its suspended matter, and where filling in to a total height of six feet, the operation can, if desired, be carried out in two steps, first to a height of three feet, and then, after the draining and consolidation of this base has been effected, the second half can be similarly raised. The double operation gives facilities for neater finish and affords also the chance of cutting a shallow canal through for its full distance in one-half the time that would otherwise be necessary to effect a through communication. Where lateral banks are not



SECTION THROUGH STOKEHOLD OF SEA-GOING PUMP DREDGER, TYPE B.

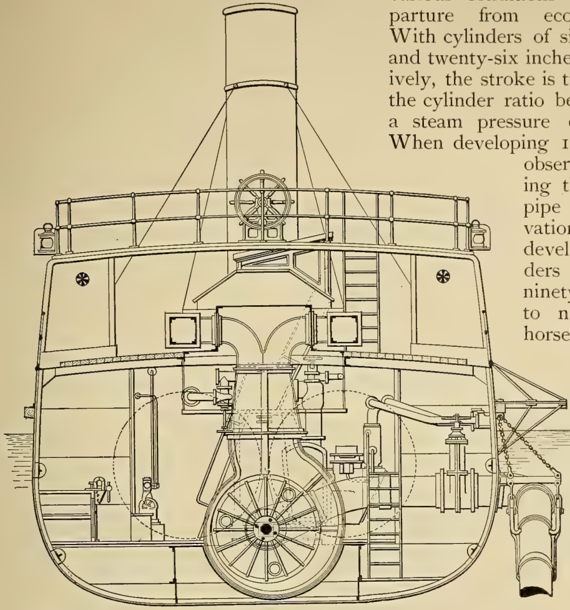
required, the pump dredger may often be used to distribute the spoil conveniently along the route.

The illustration of type A is taken from a ferrotype of machines constructed under the writer's direction for canal and drainage operations in the Argentine Republic. The discharge or mud pipes are of thin plate iron, secured upon rafts of petroleum barrels or iron caissons, the disadvantage of which latter is the risk of perforation and sinking. The joints are of thick leather, copper riveted and dressed with horse-tallow. The amount of water necessary to secure the carriage of the spoil varies with the nature of this, as high a ratio as ten to one being found necessary on the Weser when pumping heavy sand to a distance of about 2600 feet, and the smallest ratio with peaty clay or silt being perhaps three to one. In raising land or forming banks, it is well, as a matter of fuel economy, to keep down the end of the discharge pipe to its lowest possible level, raising it only as the land level is filled up. A convenient size for a non-propelling dredger of this type is 110 feet in length, twenty feet in breadth, and eight and one-half feet in depth, the draught being four feet three inches. The hull is simply of rectangular cross section, with ends semicircular in plan, the boiler being placed aft to balance the ladder. To dredge a depth of about twenty-six feet, the ladder will be about fifty-six feet long from the centre of the lower tumbler to the point of suspension on the tower. The buckets will be thirty-two in number of about ten and one-half cubic feet capacity, the chain links being of flat bar iron 4½ by ⅞ inch and two foot pitch. The general design of the dredger presents nothing differing from ordinary machines, there being the usual complement of anchor and ladder winches.

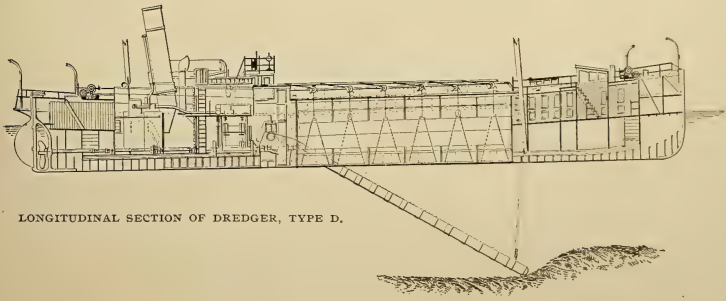


CROSS SECTION OF BUCKET DREDGER WITH MUD PUMP, TYPE C.

The chief points in the design of a self-contained pump dredger are seen in the gearing and engines. For a bucket speed of twelve per minute, the mud pump fan is about thirty-nine inches in diameter and nine inches wide, its rate of revolution being from 280 to 300 per minute, which corresponds with a theoretical height of discharge of about forty feet of water, and in practice it discharges freely at thirteen feet of height through a length of about 500 feet. The ratio of pump speed to engine speed is 1:3.35, and, as there is but one pair of engines driving both the buckets and the pump, it is important to provide for changes of speed to suit varying work. The arrangement hit upon is simple and well contrived to fill various conditions without serious departure from economical working. With cylinders of sixteen and one-half and twenty-six inches diameter respectively, the stroke is twenty-seven inches, the cylinder ratio being thus 1:2.27 for a steam pressure of ninety pounds. When developing 152 horse-power, as observed, when delivering through 500 feet of pipe at thirteen feet elevation, the ratio of power developed in the cylinders is as fifty-five to ninety-seven and as fifty to ninety-one for 141 horse-power, the low-pressure cylinder doing the larger share. The engine shaft carries two pulleys, that to drive the buckets being nearer the high-pressure crank. The mere effort of driving the buckets alone with the high-pressure cylinder exhausting to the air requires twenty-one and one-half horse-power. To do the same work with the whole

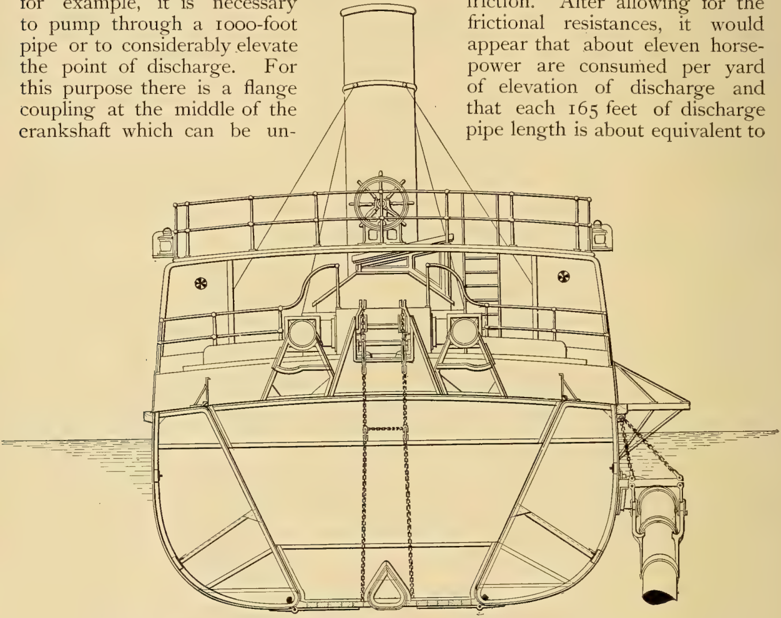


HOPPER SUCTION DREDGER, TYPE D.—SECTION THROUGH ENGINE ROOM.



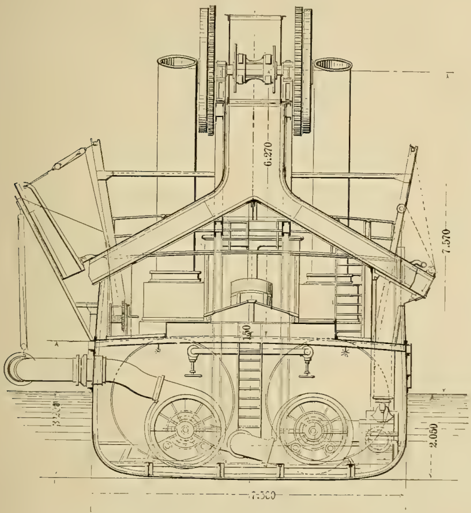
LONGITUDINAL SECTION OF DREDGER, TYPE D.

engine demanded forty-four horse-power, the excess being that due to the low-pressure cylinder friction and to the air and circulating pumps. Of the total 152 horse-power about 100 or 110 is absorbed by the Slurry pump. Hence the propriety of driving this from near the low-pressure crank. There are times when it is desirable to run the cylinders independently, when, for example, it is necessary to pump through a 1000-foot pipe or to considerably elevate the point of discharge. For this purpose there is a flange coupling at the middle of the crankshaft which can be unbolted for free running. By this means the pump can be run faster to suit the head against which it is called to work and to raise the proportion of water to solid matter. A live steam pipe also admits steam direct to the low-pressure cylinder, raising the forward pressure on this and the back pressure on the small cylinder, and thereby suiting the two cylinders to their duty. The working of the whole machine is thus very elastic. The driven pulleys are connected to their respective shafts by friction clutches worked from the deck, that actuating the pump slipping if a stone or other obstruction blocks the fan.



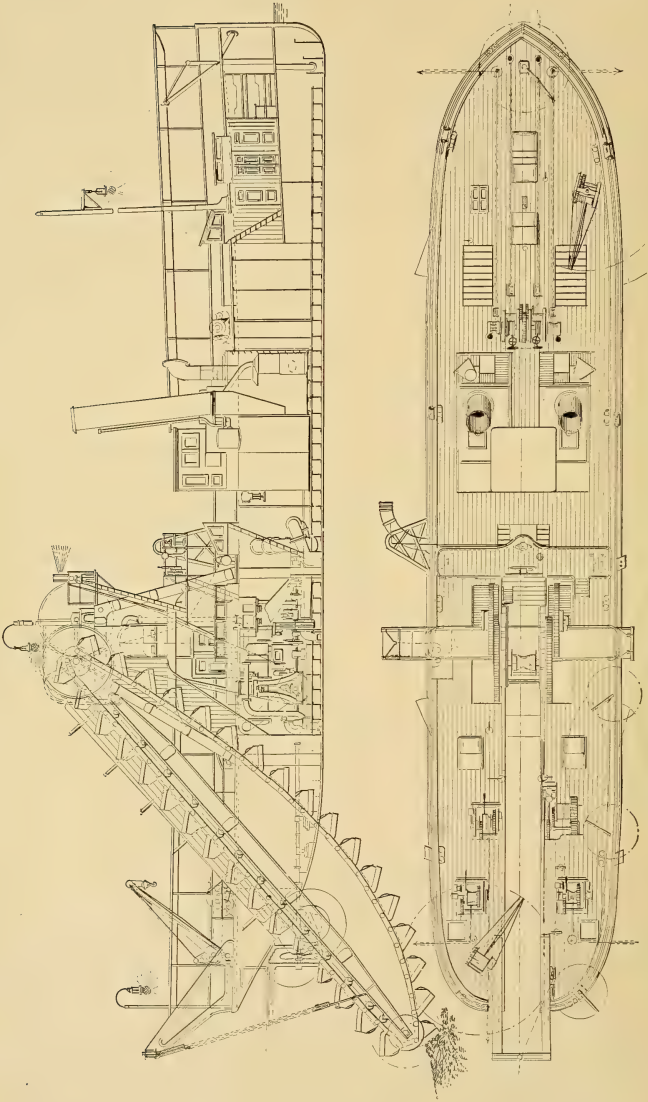
HOPPER SUCTION DREDGER, TYPE D.—SECTION THROUGH HOPPER.

In testing dredgers of this type at Amsterdam the writer found that while it required barely twenty-two horse-power to dredge with the high-pressure cylinder, it required over forty-four horse-power with the entire engine as above stated, the excess, nearly twenty-three horse-power, being due to friction. After allowing for the frictional resistances, it would appear that about eleven horse-power are consumed per yard of elevation of discharge and that each 165 feet of discharge pipe length is about equivalent to a little over three feet of elevation in respect to the power required to overcome the frictional resistance. When working water only, the length resistance is only about a third of this. The pressure gauge showed sixteen and one-half feet for water and twenty-three feet for mud when the mud pipe was 500 feet long and the volume pumped was about 1570 cubic yards per minute. This showed a ratio of water to solid of about six to one. The engines will work, when in order, at the rate of about twenty pounds of water per horse-power per hour. There appears to be a rule of general acceptance among dredging engineers that the speed of the dredging chain should be about twelve buckets per minute irrespective of the pitch. Thus a long pitch of chain implies a much higher velocity of the cutting edge of the buckets and the conclusion to be drawn is that bucket speed is often too slow. There is also a tendency to make the chains much heavier than is really necessary. As a matter of fact, dredging is not an operation which calls for a great expenditure of power. The pump is the chief power absorbent, and in the Weser machines the chains have been kept much lighter than ordinarily they would be. In the dredgers just described the chain speed was about forty-seven feet per minute, the pitch being two feet. With a pitch of two feet eight inches the velocity would be about sixty-three feet and cases are recorded of as high as seventy-nine feet. Ample steam for the work to be done is produced by a double furnace boiler measuring eight by seventeen feet with thirty-one and one-half square feet of grate surface and furnaces three feet in diameter. There are 138 tubes seven feet six inches by three inches, and the pressure is ninety pounds. This boiler supplies the anchor and ladder winches also. The pump may be run as fast as 300 turns per minute, but this should be regulated to the length and elevation of the discharge, any speed in excess of that necessary to discharge the spoil at a proper consistency representing so much wasted fuel. To prevent settlement in the mud pipe, the pump should be run for at least one minute per 300 feet of pipe after the stoppage of the dredging chain. This clears the mud pipe of spoil. The pump should also be set in motion before the buckets. Where the use of the floating pipe is inconvenient a pump dredger may discharge upon a shoot carried upon a tower which may run on a track laid alongside the canal. Such a shoot is made wide at its receiving end to allow for the swaying of the dredger and its weight is carried by guys or stays from a pole or mast.



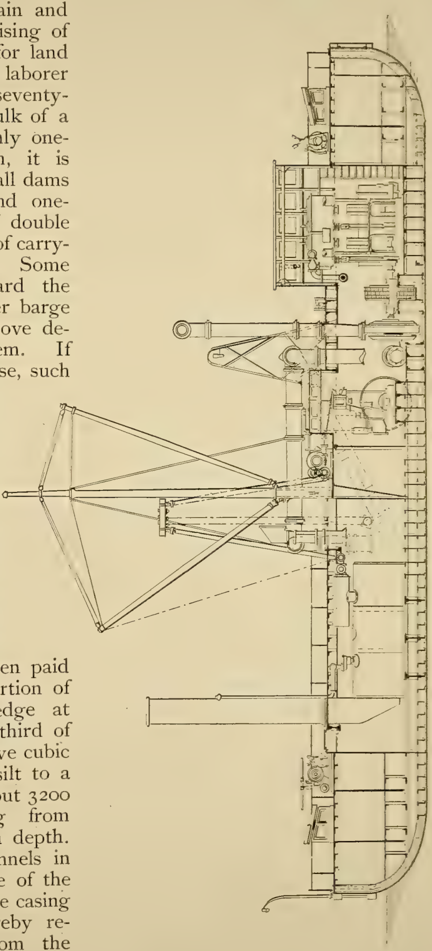
CROSS SECTION OF DREDGER "SAMSON" BUILT FOR THE PRUSSIAN GOVERNMENT.

The Hollanders are by no means conservative in their mechanical methods and appear to employ dredgers of an endless variety of combination, carrying on the excavation of loose, dry sand by means of the undercutting chain of buckets, delivering direct into trucks. In this manner the new inlet works of the North Sea Canal at Ijmuiden were carried out, the large basin being excavated by the dry machine in benches of about six feet at an operation, the bucket chain having a considerable velocity and the buckets, being made to hinge on their back plates, opened and discharged their contents as they passed over the top tumbler. When dis-



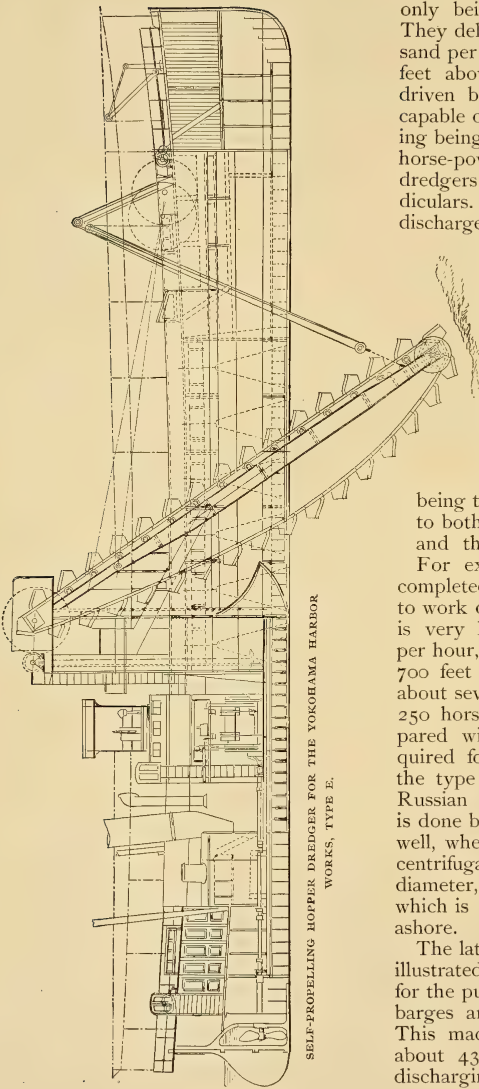
BUCKET DREDGER 'SAMSON' BUILT FOR THE PRUSSIAN GOVERNMENT, TYPE G.

charging hoppers upon land, an elevator set of buckets is sometimes made to elevate the mud to a height from which it can gravitate to the dump ; at others, the hoppers are dumped conveniently for the spoil to be raised again and pumped ashore. For the raising of small three-foot high dams for land raising purposes, an ordinary laborer will throw up a length of about seventy-five feet per day. As the bulk of a dam about three feet high is only one-fourth that of a six-foot dam, it is obvious that the cost of two small dams is only one-half in material and one-fourth in labor of one dam of double height, showing the advantage of carrying out such work in sections. Some of the Dutch engineers regard the system of discharge from hopper barge to land by the mud elevator above described as the cheapest system. If sufficiently liquid for the purpose, such mud will spread over an area of about 2100 square feet. In removing an island on the river Garonne, near Bordeaux, in France, which was effected by dredging out a series of sheltered docks upon one side of the island and pumping the mud over the middle of the island to flow down on the other side, the contractors made money out of the work when paid for at 1.50 francs per cubic metre, but lost when paid only seventy centimes for a portion of the work. The harbor dredge at Ijmuiden, with buckets of one-third of a cubic metre, or about twelve cubic feet capacity, discharged blue silt to a hopper barge at the rate of about 3200 cubic yards daily, dredging from twenty-nine to thirty-six feet in depth. For working in confined channels in tropical countries, the discharge of the condenser should be run into the casing of the centrifugal pump, thereby removing the heated water from the immediate locality and helping to wash the spoil.



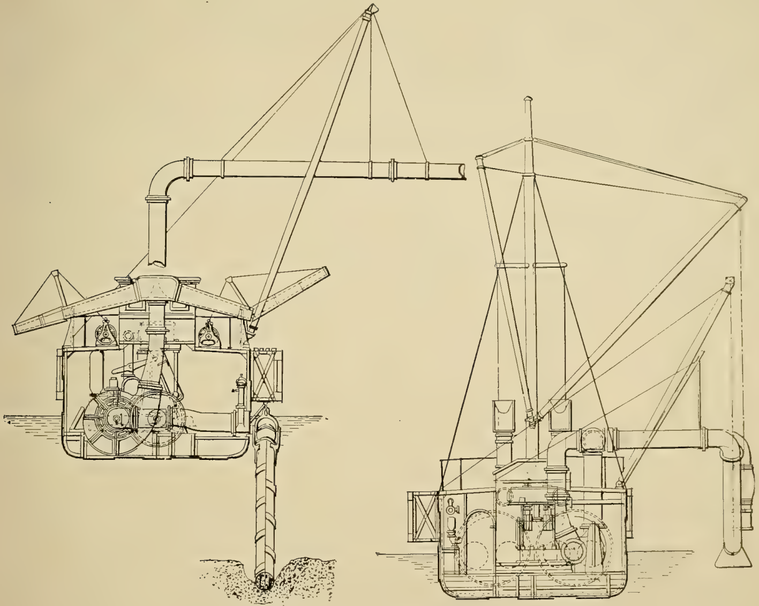
LONGITUDINAL SECTION OF DREDGER, TYPE F.

A comparatively recent development in pump dredging is the compounding of the mud pumps in the large dredgers "Goliath" and "Samson," type G, made by the already mentioned Conrad works to the order of the Prussian government for the port of Pillau. These are bucket dredgers working to a maximum distance of about 1600 feet. For this the dredged material is passed through two centrifugal pumps, placed in series, one only being used for short distances. They deliver about 260 cubic yards of sand per hour at an elevation of thirteen feet above sea level. Each pump is driven by an engine of vertical type, capable of 150 horse-power, the dredging being done by a third engine of 100 horse-power. The length of hull of the dredgers is 120 feet between perpendiculars. There are two funnels, two discharge shoots to hoppers if needed, and each of the two centrifugals has a diameter of about five feet. They are lighted throughout, for night work, by electricity, and are altogether very powerful machines.


SELF-PROPELLING HOPPER DREDGER FOR THE YOKOHAMA HARBOR WORKS, TYPE E.

The quantity of material which can be dealt with by a pump dredger is, of course, controlled by the resistance against which the spoil has to be delivered, such resistance being the sum of the resistances due to both the length of discharge pipe and the elevation of its extremity. For example, in two dredgers just completed for the Russian government to work on the River Volga the output is very large, about 327 cubic yards per hour, but the distance is only about 700 feet and the height of discharge about seven feet. The pump requires 250 horse-power, which may be compared with the 300 horse-power required for the compounded pumps of the type G just mentioned. In these Russian dredgers the actual dredging is done by buckets discharging into a well, whence the spoil is drawn by a centrifugal pump of about five-foot diameter, and is discharged by a pipe which is taken out astern and floated ashore.

The latest novelty in mud-pumping is illustrated as type F, a machine made for the purpose of discharging hopper barges and putting the mud ashore. This machine is very powerful, raising about 430 cubic yards per hour and discharging it at twenty-six-feet elevation, about 1300 feet distant, the duty calling for an engine of 400 horse-power. This pumping vessel may be used as a harbor dredger also. It has two pumps, the one to the right in the elevation drawing either from the dredging pipe alongside, or from the spout in the barge and delivering by the high delivery; the second pump, seen more to the left, will deliver water either to the barge to liquefy the spoil or to the main centrifugal pump.



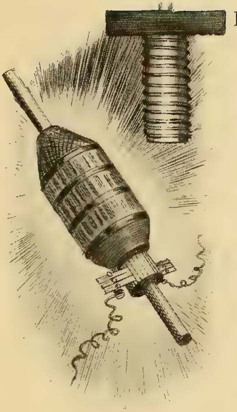
CROSS SECTIONS OF DREDGER, TYPE F.

Pump dredging is thus seen to be capable of great elasticity in its operations and may be variously applied. The writer's own experience has been sufficient to convince him of the advantages to be derived from the system in many cases where the employment of shoots or creepers would otherwise be required. In the construction of a canal with flood banks at considerable distances alongside, the system is very much more easy to apply than the system of shoots. For land raising it is especially valuable, and the extension of the system among those who have once tried it proves its value. The writer has to thank the Werf-Conrad, of Haarlem, for the drawings from which the illustrations have been prepared, and also for their courteous treatment during a considerable period of residence in Holland. In conclusion he would emphasize the importance of providing pumping power in proportion to the settling qualities of the material, heavy and coarse sand being the most difficult material with which to deal, whilst certain alluvial deposits may be pumped long distances without danger of settlement; indeed the difficulty with these is one almost of want of settling power when n to the depositing grounds.

THE LIFE AND INVENTIONS OF EDISON.*

By A. and W. K. L. Dickson.

Thirteenth Paper.



THE galvanometer department is among the most interesting in Edison's laboratory, and contains a vast collection of valuable electrical instruments, galvanometers, magnetometers, cathetometers, electrometers, photometers, chronographs, Wheatstone bridges, etc., susceptible of determining the most minute subdivisions of electricity or time. In deference to the delicate sensibilities of these appliances the fixtures of the room are constructed of brass and other non-magnetic substances. Much difficulty was experienced in the construction of this room, and in order to secure absolute stability, it was found necessary to build brick foundations to a depth of twenty-five feet and place stone tables on these for the reception of the instruments. This department is under the charge of Mr. Kennelly, the quick flash of whose humor and the delicate poise of whose faculties seem a reflex of the instruments entrusted to his care. Those sufficiently fortunate to secure this gentleman as mentor to their scientific wanderings will find their intellectual palate wonderfully stimulated by the *sauce piquante* in which the dryest items are imbedded.

Next in order come the outbuildings, devoted to ore milling experiments, and the supplementary sheds, wherein are stacked an extensive collection of barrels, boxes, kegs, containing gold, silver, copper and iron ores brought from all parts of the world. The majority of these have been subjected to the most rigorous treatment and supplied with their proper name and number. Thousands of similar samples in smaller packages are stacked in one of the upper rooms of the main building, known as the experimental ore milling department, and in this room, which is fully equipped with crushers, rolls, assay furnaces, etc., Mr. Edison may often be found testing ores and washing gold with all the zest of a Western pioneer.

In this connection we shall treat of the magnetic ore separators, a valuable branch of electrical mining, which has received most careful and successful attention. Two special types of these ore milling machines are in operation at the Ogden, N. J., mines. The machine used in the primary process is most equable in its results, has no wearing parts, and is endowed with great capacity, reasons which render it peculiarly efficient in the rough separation of the lean, low grade ores. It is a sight to witness some five or six of these monster magnets, no contemptible rivals of Sinbad's wonder working rock, bending their mysterious energies towards the extraction of the metal. The upper hoppers of the machine, when filled with the ore, are opened below, and a perfect Niagara of particles half an inch wide and thirty feet in length is allowed to rush past the magnets without touching their faces. In this downward progress a large proportion of the ore, being magnetic, is drawn inward, changing the trajectory and bringing two distinct streams into view,

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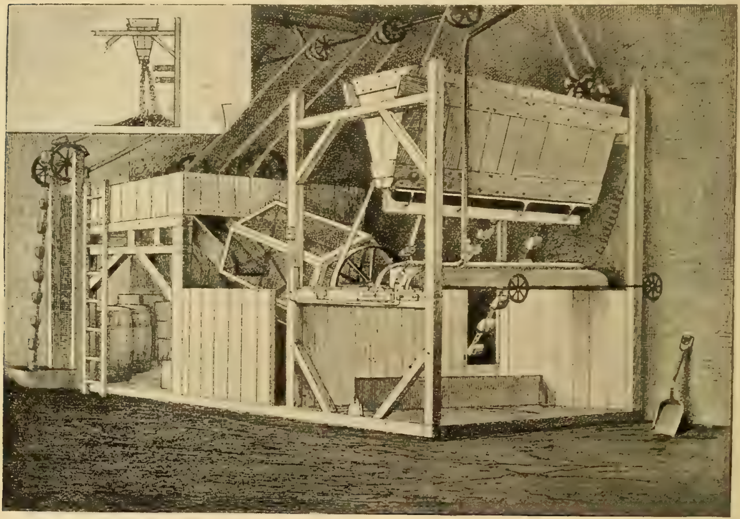
* Began in November issue, 1892.

THE GALVANOMETER DEPARTMENT.

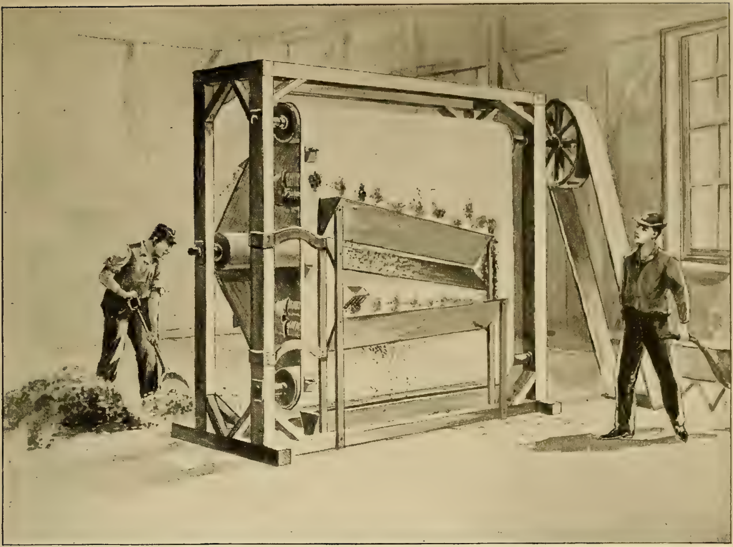
whose ultimate destination is secured by means of separate partition boards. The clouds of dust are caught up by fans and whirled away to closed compartments, where specially constructed dust separators are employed to extract the float iron.

The next process is to recrush the magnetic part, which has been drawn into the inner receptacle, by passing it through a series of rolls and reducing it to the semblance of ordinary coarse grained gunpowder. It is then fed against the second type of magnetic ore separator or refining machine, inclined rows of magnets being held rigidly in place at a certain angle, while a swiftly traveling belt, eight feet wide and over thirty feet long, is made to pass up and over the face of these magnets, tumbling and whirling the mass of particles which is thus cleansed by successive stages until it has reached the last magnet on the upper row, where the residuum is caught up in buckets, attached three feet apart to the belt, and thrown over the back of the machine into a suitable receptacle. A large number of these magnetic separators are in use at the Ogden mines, where 5000 tons a day of crude ore are crushed and magnetically concentrated.

The Orange laboratory, despite its pastoral surroundings and the pacific nature of its habitués, has been the scene of some gruesome experiments. The question of capital punishment, by means of electricity, was forcibly agitated several years ago, and the opinion of the world's leading electrical expert was naturally sought. When the new law was passed, enlisting electricity as an agent of death, Mr. Edison was consulted as to the best method of applying that mysterious and deadly fluid. To this he replied, "Hire the criminals out as linemen to some of the New York electric light companies." Later on, Mr. Edison took up the subject with greater seriousness, and became more and more convinced of the superiority of electrocution over any other method of inflicting death. He tested the comparative action of the straight and alternating currents at different intensities in connection with various criminals and arrived at the conclusion that from twelve to fifteen hundred volts alternating current would be sufficient to induce swift and painless release. In the attainment of these views not only were many painful executions necessary, but Mr. Edison's most valuable friend and assistant, Charles Bachelor, barely evaded the distinction of officiating as a sacrifice on the altar of experimental science. One of the executions alluded to was in process of completion and to Mr. Bachelor had fallen the unpleasant task of head executioner. It was desired to secure an alternating currrent, and as the gigantic dynamos in use at the laboratory furnished only a continuous current, Mr. Bachelor was reduced to the necessity of attaching an alternating device to an electric generator, used for the illumination of the streets near the establishment, and developing a current of twelve hundred volts. To this dynamo two wires were attached, one linked with a sheet of tin lying on the ground, and the other wire placed in a basin of water in close proximity to the tin. These preparations completed, the poor little mongrel, selected for scientific exposition, was conducted to the spot, where he behaved in a fashion totally unworthy of the distinction bestowed upon him. A due regard for the "eternal fitness of things" should have led him to take up his position on the sheet of tin, so thoughtfully provided, partake of the water and yield incontinently to the impulse destined to land his shade in the regions of the Dog Star, or whatever the celestial hunting fields may be, devoted to the reception of beatified canines. A perfect circuit would thus have been provided, leading from the lips and tongue of the little



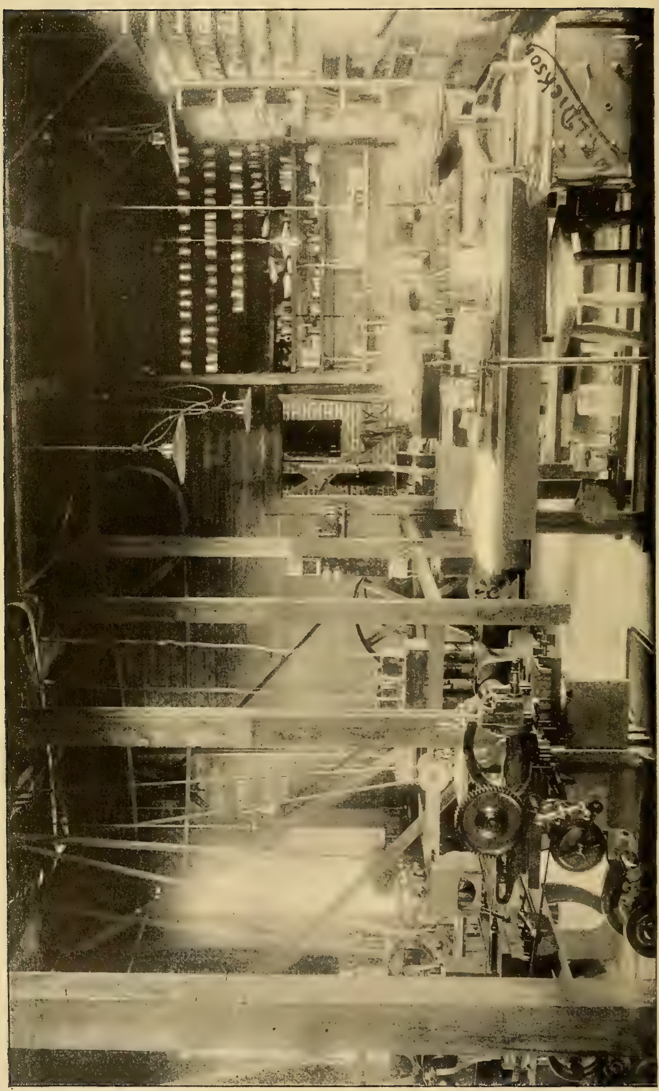
THE EDISON PRIMARY MAGNETIC ORE SEPARATOR.



THE EDISON-DICKSON REFINING MAGNETIC ORE SEPARATOR.

beast, through his head and body to his legs, and an impetus would have been administered warranted to secure that hitchless locomotion so dear to the heart of projectors. Unfortunately, the dog of low and unprogressive views refused to lend itself to the development of science, backed from the tin rostrum and rejected the water, reducing the executioners to the ignominious necessity of pulling him violently into position by means of the rope attached to his miserable little neck. Once in contact with the water, however, the results were instantaneous, the slightest possible twitching of the muscles was apparent, but beyond this there was no cry or anything to indicate suffering.

It was at about this time that Mr. Bachêlor had his narrow escape. He was mending some defective apparatus in connection with a lamp, and as it seemed to him at the time, had taken all imaginary precautions against an accident. He supposes, however, from the presence of a burn afterward found on one of his fingers, that he must unconsciously have established a circuit by holding a wire in each hand. No sooner had he made contact than he staggered back to a stool, with the awful memory of soul and body wrenched violently asunder, with such pangs as the Mahometan death angels wreak on the awakening spirits of the damned. He describes it as resembling the sensations of an immense rough file thrust through the quivering fibres of the body, a shuddering, rasping pang, grinding its way through lungs and heart. For over fifteen minutes he sat motionless, bathed in an icy and deathlike sweat, and nervously unstrung from head to foot. Yet strange to say, the shock passed away in a day or two, leaving no visible injury except in the memory of the victim. It is possible that this recuperative power may be due to Mr. Bachelor's perfection of physique. A man of less mental and physical stamina would probably have borne the traces of this adventure for the rest of



EDISON'S FLORIDA LABORATORY.

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his days, even supposing him sufficiently fortunate to escape with his life. No alternating apparatus was attached to the dynamos on this occasion. But for this fact, it is possible that Mr. Bachelor would be engaged at this moment investigating spiritual causes instead of the cruder material effects to which he has so long devoted his powers.

Mr. Edison, like many of his intellectual compeers, is personally averse to capital punishment, and regards its infliction as a relic of barbarism, destined to disappear with the advance of civilization. He believes in the most stringent restraints and in the cultivation of every social force qualified to modify or extirpate evil, but he thinks these ends may be attained by incarceration—lifelong if necessary. The terrors of protracted and solitary confinement will act as sufficient deterrents on the baser types of humanity, while those capable of better things can have their thoughts diverted into purer and more useful channels, in the selection of such work as seems best suited to their capabilities. "There are wonderful possibilities in each human soul," said Mr. Edison, "and I cannot endorse a method of punishment which destroys the last chance of usefulness." With these decided views, and with every humane instinct on the side of the suffering brute creation, it may be imagined that Mr. Edison's sympathies were only partially enlisted in the development of these ideas. It was only in the recognition of capital punishment as a necessary evil, and in the desire to render its infliction as painless as possible that the inventor lent himself to the task of investigation. The commission appointed by the State of New York to test the efficiency of the proposed methods was permitted to use a building in the rear of the Orange laboratory and supplied with electrical appliances, together with the assistance of skilled members of Mr. Edison's staff, notably Mr. A. E. Kennelly. The application of the fluid was relegated to Dr. Carlos F. MacDonald, medical superintendent of the Auburn Asylum for Insane Criminals, assisted by Dr. A. D. Rockwell, one of the most noted electricians of our age; Dr. Edward Tatum, of the University of Pennsylvania, and Mr. Harold P. Brown, electrical expert, by appointment of the State. The points for decision were the kind of current to be employed, the amount of destructive force necessary, and a place of application. Four dogs, a horse and four calves were provided for the purposes of investigation. The first practical exposition of these kindred experiments was far from successful, but later tests brought unsuspected facts into view, and electrocution is steadily winning precedence as the least objectionable form of judicial killing.

A miniature edition of the Orange laboratory is the building at Fort Meyers, Fla., erected for the entertainment of the inventor, whose ideas of relaxation are much on a par with those of that active female who requested her spouse to cut up a cord of wood while he was resting. But for the salutary outlet which such establishments afford, there is reason to believe that Mr. Edison would suffer from a veritable plethora of ideas, and perish eventually with intellectual apoplexy. As it is, he has been enabled to ultimate his thoughts under conditions highly favorable to mental development. The laboratory is excellently equipped, though necessarily upon a less sumptuous scale than the parent establishment. It is supplied with dynamos, steam engine and boiler, shafting, lathes, drill presses and planers, scales, electrical measuring instruments and all other needful tools. The chemical department is very complete; running water is supplied from a large tank on the roof, being pumped up from a deep well by means of a windmill. A gas generating apparatus is also comprised in the fittings of the department.

A roomy house of the Queen Anne style stands within easy proximity to the laboratory, and is supplied with every convenience which the heart of reasonable man could desire. It commands a wide prospect of flowering gardens, studded with tropical palms, through the soft vistas of which the crinkled silver of the Calahoutchie river may be seen. Samuel Edison, the father of the inventor, and Mr. James Symington, a friend of thirty-seven year' standing, spend the greater part of each winter in this congenial resort, and are triumphant vindications of its peaceful and salubrious influences. Mr. Edison, Sr., in particular, exhibits a mental acuteness and physical energy which furnish a singular contrast to the self-indulgent humanity of the day. He relegates to no one the task of cultivating these domains, and may be seen at early dawn, as well as during the hottest hours of the day, tilling the ground in true patriarchal fashion.

A more easy going, contented, not to say lazy and lethargic, spot than Fort Myers it would be impossible to find outside the geographical limits of Lotus Land. To these pleasing qualities is due the present condition of street lighting at the Fort. Thomas Edison, on the occasion of one of his flying trips, undertaken for hygienic reasons, offered to furnish Meyers with a system of electric lighting, provided the Meyerites would furnish the poles. This handsome proposition, at which any corporation with a modicum of enterprise would have jumped, was languidly refused, and Mr. Edison, disgusted with the lethargy of his beneficiaries, left them to the time-honored radiance of a tropical moon and the phosphorescent lights of the Calahoutchie river. The latter phenomenon is curious and beautiful enough to furnish some excuse for the contemplative indolence of the natives.

(*To be concluded.*)

A NEW INCANDESCENT ARC LIGHT.

By L. B. Marks.

ELECTRICAL literature is replete with studies of the incandescent lamp as a source of artificial illumination, and the performances of arc lights under a great variety of conditions have also been published from time to time; but the subject of the so-called incandescent arc, singularly, has received little or no attention. In view of this fact the author deemed it desirable to report, at the recent International Electric Congress at Chicago, on a series of investigations which, though still incomplete, have disclosed some remarkably interesting and important phenomena with reference to a new form of incandescent arc light. The experiments have been carried on far enough to demonstrate that this source of illumination is *sui generis.* While possessing the main characteristics of the ordinary arc, it is also akin to the incandescent light, and may be said to constitute a mean between these two.

The incandescent arc has been described as one in which the "two electrodes are in imperfect contact," the current thereby meeting with a high resistance and producing heat effects which manifest themselves in the incandescence of one electrode and the formation of a number of very small arcs between the uneven parts of the electrodes in contact.

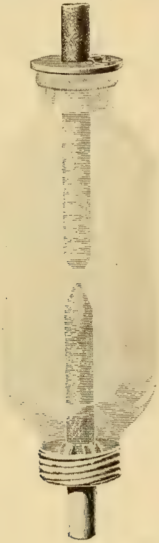
On this principle Reynier, Werdermann, Joel, Tommasi and others constructed lamps years ago, but for well known reasons none of these "semi-incandescent" lamps, as they were called, found much practical application. The sun lamp of Clerc and Burean was a modification of the others, the arc impinging on the surface of a block of marble or condensed magnesia between the tips of the electrodes. In this form there was a rapid waste of the non-conducting substance interposed, and a dimunition in the efficiency of the light.

The incandescent arc here treated of differs radically from any of the forms alluded to above. In it the electrodes are not in contact, while the current is indirectly used in maintaining all the products of disintegration of the carbon in a state of incandescence or opalescence. The accompanying illustrations show the main features of the appurtenance. It will be seen that the arc is enclosed in a small envelope, which is made of highly refractory glass. The envelope is closed at the bottom and provided on top with a metal plug having an opening in it just large enough to admit of the feed of the upper electrode. A fireproof plug of asbestos pulp insulates the metal from the glass. A valve shown in the plate allows the egress of gas, but prevents ingress of the air. With this construction the operation of the lamp will be as follows:

Upon the closure of the circuit and the springing of the arc, the air in the enclosing envelope is robbed of its oxygen, the latter uniting with the carbon of the electrodes to form carbonic oxide and carbonic acid gases. These are brought to an exceedingly high temperature at which they maintain the carbon vapor issuing from the arc. This vapor is deposited in the form of a thin coating on the internal surface of the glass chamber.

The expansive force of the gases may become sufficiently great, if no means of egress be provided, to rupture the envelope; hence a small safety valve is provided for their outflow. The only possibility of ingress of air is through the narrow space between the positive carbon and the plug; experience has shown that after the temperature has been raised beyond a certain point the amount of air that enters in this way is inappreciable; in any event, the oxygen is immediately converted by combination.

It is important that the enclosing glass envelope be as small as possible, for the conservation of the radiant energy, and hence the efficiency, will depend largely upon the size of the chamber. The heat which in the ordinary arc light is dissipated in the air is here conserved and raises the temperature of the enclosed gases and vapor of carbon. The proper conditions being fulfilled, the lamp maintains its maximum efficiency shortly after the current has been passed through it, and glows like the incandescent with the brilliancy of the arc light. The arc proper is scarcely visible, but the entire contents of the chamber seem to be luminous, giving the appearance of a solid cylinder of light.



THE LAMP COMPLETE.

The pressure, as well as the temperature of the enclosed gases, has a very important bearing on the performance of the lamp, and affects to a marked degree the character of the carbon deposit on the glass chamber. At this date no definite figures can be given, but it appears that a high tension is absolutely required to give good results. The structure and constituency of the electrode are also pre-eminently important. Absolute purity of the carbons is imperative.

Investigators in this field have apparently found it impossible to obtain all the requisite conditions.* Beardslee, in a United States patent in 1882, mentions a type of lamp similar to the one under discussion, but whether the size or character of the arc-enclosing chamber, the nature or management of the gases, or the quality of the electrodes, or other features, made his arrangement impracticable, is not recorded. Suffice it to say, the comparatively poor grade of arc light carbon manufactured ten years ago would alone explain his failure.

It is interesting to know here that attempts have been made at various times to save carbons in arcs by excluding the oxygen of the air. Baxter, in 1883 and 1884, devised several forms of arc lamp with this object in view. The subject has been more recently referred to by Elihu Thomson in a paper on "The Electric Arc and its use in Lighting," read before the National Electric Light Association. These experiments were attended with little practical success, not because the desired ends were infeasible, but probably because, as in the case of Beardslee's apparatus, alluded to above, one or more of the requisite conditions had not been attained. It appears that the saving in life was more than counterbalanced by the loss in light. The "incandescent effect" was absent, and the unsteadiness of the arc itself was fatal. The results were almost identical with those obtained when the arc is formed *in vacuo*. In this case there is a tendency of the carbon to deposit as a soot on the sides of the vacuum chamber, an effect consequent upon the vaporized carbon in the arc being carried off and condensed again as soon as the vapor escapes the heat of the arc stream.

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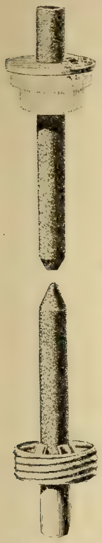
* David L. Salomons, of Turnbridge Wells, England, in a letter to the London *Electrical Review*, claims to have made and used a lamp like that described by Mr. Marks as far back as 1882 In order to avoid the difficulty of passing the carbons through a closed globe, he used a Jablochkoff candle. The apparatus, he says, was made for him by Messrs. Baker, of Holborn.—THE EDITOR.



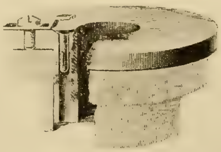
THE CARBONS.

But the requisite conditions herein before named being once attained, the arc is really a beautiful phenomenon. It differs in many respects from the arc in open air, being especially steadier than the latter. The light emanating from the incandescent vapor of carbon appears to issue from all parts of the small enclosing envelope, the area of the source of illumination being limited only by the size of the chamber.

Measurements of the efficiency and candle-power of the light were made in the laboratory of Cornell University and showed that, while the mean efficiency of the ordinary arc is about ten per cent., and the mean efficiency of the regular incandescent lamp is rather below than above five per cent., the efficiency of the new light lies between these two, approaching, however, more nearly that of the arc. The distribution of light, as shown by candle-power tests, differs considerably from that of the ordinary arc, the explanation of this difference undoubtedly lying in the quality of luminosity of the light emitted by the incandescent arc. Luminosity is a potent factor in determining the real efficiency of any source of illumination. Lack of time has prevented the investigation of this important phenomenon, but, at its maximum efficiency, the light from this form of incandescent arc, though not so intense, unmistakably appears brighter than that of an ordinary arc of equal candle-power as interpreted by the photometer.

Oxygen being practically excluded from the arc-enclosing chamber, prolongation in the life of the electrodes is an implied concomitant. In the ordinary arc while the positive carbon loses by volatilization from its tip or crater, and by combustion from its sides, the negative gains no deposit, but wastes at a less rate than the other, and by combustion only. Hence, if the exclusion of oxygen were complete, we might expect an indestructible negative. This condition, however, has not been fulfilled in any of the tests made thus far, but the results fully substantiate the theory. Absence of combustion on the one hand, and the tension of the enclosed gases on the other, combine to greatly reduce the amount of disintegration of the positive electrode.

The preservation of the negative is a very interesting feature of this type of lamp. There is a marked tendency toward deposition of the products of volatilization of the upper electrode, on the tip of the lower, the carbon deposited, if not ruptured by the action of the lamp, forming an integral part of the negative. In one case where the arc having been sprung, the electrodes did not come in contact during the entire run, this "building up" process was beautifully exhibited, the negative electrode gaining practically all that the positive lost.



PLUG FOR TOP OF GLOBE.

The effect of the enclosed gases on the form and character of the arc presents a large field for investigation.

On account of lack of sufficient data no attempt will now be made to state much of a definite nature regarding this subject. The difference in potential between the electrodes being equal, the incandescent arc is longer for a given current than the ordinary arc ; under some conditions it has been found to be almost twice as long. If we accept the conclusion of S. P. Thompson that "the arc is independent of the nature of the surrounding gas," we must then look to the effects of the tension or pressure of the heated gases upon the arc to explain the difference in length. It has been found that there is a constant increase of potential difference with pressure above atmosphere, for a given current and length of arc. But, in spite of this fact, the decrease in resistance of the arc under the conditions named appears to allow of a greater length for the same potential difference.

In the ordinary arc the carbon vapor carried off from the positive is consumed by the oxygen of the air before it can deposit on the negative. Hence the ever-present "zone of flame," as distinguished from the arc-flux proper, is really a zone of combustion. In the incandescent arc, however, there is naturally no zone of flame; consequently the phenomenon of flaming, common to the ordinary arc, does not occur. The arc tends to centre itself, being probably aided in so doing by the pressure of the surrounding gases; moreover, the slow consumption of the electrodes lessens the tendency to wander. With cored carbon there is a perceptible crater, but with solid pencils the tips become more or less flattened.

The quality of the carbon has an important bearing on the potential difference between the electrodes. Generally speaking, it has been observed that with soft, fine-grained carbons the potential difference is considerably lower for a given current than with harder or coarse-grained pencils. The tendency to hiss, however, is not so marked when the electrodes are consumed in the gas chamber as in the open air; in the former case the disintegration is so slow that the "electrolytic" vaporization, as it has been called, does not appear to explode the particles. It is interesting to note here that these results confirm the theory of hissing advanced by Prof. Thompson a few years ago.

No measurements were made using the alternating current; but the appurtenance was applied to the alternating current arc lamp to determine the effect on the noise of the arc. The hum was in a large measure reduced, but whether the reduction was due mainly to the mere fact of the arc being enclosed in an air-tight compartment or not is questionable. But, as the hum became much slighter after the lamp had been in operation several minutes, the action of the heated gases being then manifest, it is plausible that the diminution in the noise was not due entirely to the shielding property of the glass envelope.

While it has been proven that the humming of the alternating current arc is due to the rapid periodic extinction and re-establishment of the discharge, the singing tone may be greatly modified, if not entirely overcome, by the substitution of any incandescent arc of the Reynier type. A few years ago the writer had occasion to test an alternating current arc lamp trimmed with carbons which had been provided with a core of pulverized mica and carbon. The springing of the arc was accompanied by the usual hum, but as soon as the mica fused, the noise ceased. The conditions were similar to those of an incandescent arc, the plastic mica-carbon core constituting a high resistance medium between the plus and minus electrodes. There was really no true arc. The amount of light was naturally greatly reduced. In the case of the incandescent arc first alluded to, there seems to be an approach to these conditions, the arc-stream acted upon by the gases enclosed in the chamber appearing to have a greater density, if we may call it that, than under normal circumstances. The amount of light in this experiment was, however, apparently as great as in the direct current tests.

Unquestionably this form of incandescent arc must have a wide application to the arts. As a substitute for the ordinary arc light, where greater steadiness or longer life is required, its superiority will be manifest, and its utilization, where at present the incandescent lamp is the only satisfactory source of illumination, also presents a large field. The effective distribution of luminous energy and the color of the light make it for many purposes a desirable mean between the incandescent and the arc. As a standard source of illumination for arc light comparison and measurements, it may be of much scientific as well as utilitarian importance.

The investigations have been carried out under the direction of Louis E. Howard, and many of the facts herein stated are due to him. The writer is also indebted to Dr. Edward L. Nichols, Franklin L. Pope and Robert H. Read for valuable suggestions; to C. Ransom for life tests, and to William C. Hubbard and E. S. Ferry for assistance in the efficiency and candle-power measurements.

GOLD STAMP-MILLING.

By T. A. Rickard, M. Am. Inst. M. E.

MILLING, as defined by the author in a paper presented at the recent International Engineering Congress at Chicago, is one of the metallurgical arts whereby the extraction of the largest possible proportion of the value in an ore is effected at the least possible expense. Stamp-milling is that particular process in which a heavy body of iron is caused to fall upon the ore so as to disintegrate it and thereby induce a separation between what is valuable and what is worthless. The latter is usually less in specific gravity, and is therefore, by the further aid of water, removed from the former, which is then collected by the use of mercury.

Several similes have been employed to describe this process. The stamp has been likened to a hammer of which the stem is the handle and the die the anvil. The ore upon which the stamp falls has been compared to a nut awaiting the descent of the hammer whose blow is to separate the valueless shell, the quartz, from the valuable kernel, the gold.

When we begin to pursue our inquiries, however, we find that the analogy is just sufficiently true to emphasize the departures from it. The hammer falls, the anvil is fixed; so with the stamps and the mortar. The anvil is made of softer metal than the hammer; so also the die is often, and should be always, of steel or iron less hard and more tough than that of the shoe. The movement of the hammer and the drop of the stamp are both intermittent.

In regard to their intermittent action, as in many other respects, stamp-mills arrange themselves under two types, which, though apparently contradictory, have both been evolved from a common original, and are united by a great variety of intermediate modifications. The slow speed and the high drop of the mills of Gilpin county, Colorado, appear to have very little in common with the fast speed and short drop of those of the main gold belt of California; yet the practice of the one was largely derived from that of the other, and each has been adapted to the treatment of the ores of its particular region.

The first and most apparent difference is that of speed. In Colorado the drop is regulated at thirty per minute, while in California it averages from ninety to one hundred and five. The more rapid drop gives a less intermittent action, and in this respect more nearly approaches the ideal machine.

The work done by the hammer is, however, dependent not only on the rapidity of its blows but also upon its weight and the distance through which it falls. Keeping to the two types, which we have chosen as representatives of the two systems of milling, we find that in Colorado the stamp weighs 550 to 600 pounds and falls a height of eighteen to twenty inches, while in California the stamp weighs from 750 to 850 pounds and drops only four to six inches. Upon multiplication of these three factors—weight, drop and speed—we find that the theoretical work done is nearly equal and is about one horse-power.

In milling, however, the efficiency of the stamp as a crushing machine is gauged by the quantity of ore which it can reduce, and we find that this does not at all correspond to the theoretical equality of the mills. In Colorado the stamp crushes one ton per twenty-four hours, while in California, with an ore of similar hardness, the amount is from two and a half to three times as much. Why is this difference? To explain it we must suppose the hammer to fall not upon the dry and wide surface of an anvil, but upon a face of iron confined within a narrow box and under water. This box corresponds to the mortar or coffer of the stamps. It has no opening save in front, where a metallic grating or screen permits the escape of only that part of the material which has been crushed sufficiently small to pass through the openings. The ore upon the die is under water. The depth of that water depends upon the level of the bottom of the aperture occupied by the screen-frame. In Colorado the depth of discharge, as measured by the distance from the bottom of the screen to the top of the die, is fourteen inches, but in California it is four inches only. Herein lies the key to the difference in the crushing capacity of the two mills. Though the same amount of power be expended, and though the screen used be of similar mesh, yet in the Colorado mill the stamp falls through ten inches more of water and has to discharge the pulp at a level ten inches higher than in the California mill. The greater depth of discharge deadens the effectiveness of the blow of the stamp and weakens the force of the splash. Another result is obtained. While the screen does not in either case succeed in sizing the material discharged through it, yet it will be found that, though provided with similar screens, the pulp issuing from the deep mortar has a fineness much greater than that discharged by the shallow one. The pulverized ore is retained by the deep mortar long after its particles have been crushed to a size permitting their passage through the screen-openings, and they therefore become repulverized to a further degree of fineness.

This touches upon one of the points in respect of which the stamp-mill is most faulty. By actual test it is found that, though using a forty-mesh screen, for instance, with the theoretical supposition of crushing to that particular size, yet in a Colorado mill fully seventy per cent. of the pulp, and in a California battery about fifty per cent., will pass through a 100-mesh sieve. The percentage varies with the character of the ore, but these figures may be considered fairly representative. Two causes are chiefly responsible for this. The most important in its effects is the pause which occurs between the successive drops of the stamp. In a Colorado mill the interval is two seconds; in California it varies from three-fifths to two-thirds of a second. Particles of ore, which have been pulverized to a fineness which would permit of their exit through the screen, are enabled to settle toward the bottom of the mortar. It would be expected that the heavy metallic minerals occurring in the ore would, because of their greater specific gravity, be most affected by this feature of the treatment. In practice this is found to be so. The fine slimes contain a large proportion of metallic sulphides, generally valuable on account of their close association with the precious metals, while the coarsest particles to be found in the tailings usually consist of quartz and other minerals forming the less heavy gangue. The want of any proper control over the regular sizing of the pulp is also due to the unequal and irregular splash of the water in the battery and the haphazard way in which the particles of pulverized ore strike against the screen. In the case of any single particle, for instance, it is a question of hit-or-miss whether it be thrown against an opening or a blank. If it fail to pass through, it is thrown back by the recession of the water and undergoes a further agitation and probable pulverization.

In practice this feature of the stamp-mill is recognized by both the California and the Colorado millman. On the Pacific coast the mortars are made narrow, thereby diminishing the opportunities for the settling of the particles of ore, and, by increasing the force of the splash, adding to the chances of its exit through the screen. In late years there has also been a tendency to use wire-cloth in place of punched iron, for the reason that the former, though having openings of identical size, yet has more of them per square inch than the latter, and, therefore, presents a greater area of discharge. By giving an inclination of ten degrees to the screen-frame, the exit of the pulp is further assisted.

In Colorado, this defect of the stamp-mill has been utilized, and has been made an assistant to the millman. The mortars of this district are wide and roomy, the splash of the water inside the battery is weak, and the pulp remains inside until pulverized to a fineness much exceeding that required for its passage through the screen. There is a reason for this apparently contradictory feature of the milling practice. To explain it we must glance at the ore. We find it to contain an average of fifteen per cent. of pyrite. The gold is very fine and intimately associated with the pyrite. To separate them it is necessary not only to crush to a certain degree of fineness, but also to obtain conditions which will permit the gold when once separated to settle upon amalgamated plates placed inside. The deep discharge causes the pyrite to remain in the mortar-box long after it has been pulverized to a size smaller than the screen-openings; the long drop gives the interval of time required to allow of the settling of fine gold, while the roomy character of the mortar aids the deep discharge in affording a chance for the gold to get out of the way of the falling stamps and to become amalgamated upon the two copper plates inserted at the back and front of the mortar. In this way about two-thirds of the total yield of amalgam is obtained inside the mortar. In California the introduction of plates is not admissible in mortars having so shallow a discharge as four inches, because the more constant and more violent agitation of the pulp prevents the settlement of the gold and would cause the abrasion or "scouring" of the surface of amalgamated plates. A certain varying percentage of gold is, indeed, usually arrested inside, partly by the aid of mercury added to the ore as it is fed into the battery, but this is of such a coarseness that gravity alone would serve to keep it within the mortar.

We have now entered into the discussion of the effects produced by the action of the stamp upon the ore. In many respects it departs from the analogy of the hammer which cracks open a nut. While being lifted the stamp also turns. This is effected by the friction of the cam-surface against the under side of the tappet. In a slow-drop mill the stamp makes a complete turn each time it is lifted, but with an increased speed this action is more uncertain and from 4 to 10 drops are required to make a whole revolution.

This feature of the stamp-mill breaks the analogy to the hammer and anvil, and causes it to resemble the pestle and mortar. The turning of the stamp in rising is communicated to the ore when it falls and induces a grinding-action, which has important results. The mere impact of the stamp upon the particles of gold has the effect of hammering it, of increasing its density and of preventing its amalgamation, while the turning of the shoe upon the die causes the abrasion of the surface of the gold and the rubbing off of any film or foreign matter, which, by preventing contact between the gold and the mercury, is prejudicial to amalgamation. In grinding the ore the stamp, however, also tends to convert it into slime. The hammer which cracks open the nut liberates the kernel without smashing it, but in pursuing the simile we find that the stamp not only breaks the shell, but both the kernel and the shell are further crushed, and their particles become confused together. The stamp which frees the gold from the quartz has to deal with a material in which the valuable and the valueless constituents are so uneven in size and so intermixed that the one is often crushed too much and the other too little.

I have seen auriferous quartz at Clunes, Victoria, Australia, which very nearly approached our simile of the nut. The gold occurred in seams and cavities in a quartz which had a honeycombed character. With such an ore there is just a certain blow which will break the brittle quartz and liberate the ductile gold. Such ideal conditions are very rare. The different parts of the same ore usually vary both in hardness and composition. The same work done on two pieces of mill-stuff will produce entirely dissimilar results. In the stamp-battery the heavy sulphide minerals are pulverized to a greater fineness than the siliceous gangue. When the gold is not too closely associated with the pyrite, coarse and rapid crushing will produce an adequate separation; but when the metal is in a finely divided condition and very intimately mixed with the pyrite, then fine crushing is demanded and can, unfortunately, only be obtained by the production of a very undesirable excess of slimes.

We have glanced at the results produced by the turn of the stamp upon the ore. Upon the mechanism itself the results are beneficial. The revolution of the stamp equalizes the wear upon the shoes and dies. It tends, also, by maintaining an even crushing-surface, to prevent that decrease of efficiency which occurs when either hammer or anvil has an irregular face.

Water is the vehicle used for the removal of the valueless portions of the ore from those which are valuable. Its low specific gravity as compared to both the metal and its enclosing gangue enables us to use it as a medium for their separation. A liquid having a specific gravity greater than that of water, and intermediate between that of the gold and its gangue, would be more effective if its use were practicable, which it is not.

In the mill, however, specific gravity is not the only factor we have to consider. The water discharged from a stamp-mill often transports the heavy pyrite further than the light quartz. This is due to the fact, already referred to, that the pyrite remains inside the mortar longer than the quartz and becomes pulverized to a further degree of fineness. It, therefore, presents a larger surface to the water. Again, the metallic sulphides commonly occurring in gold ores have a cleavage more highly developed than that of quartz; therefore, while the latter finds its way into the water in irregular and angular grains, the former will be found in thin plates and flakes, which readily float upon a running stream.

Water is the fluid used, but air also plays its part. During the time of its violent agitation under the falling stamp, the water entangles a certain amount of air. Such air exists in the form of small bubbles which hold the finely-pulverized ore in suspension and thus become the main agent in the floating of the slimes. Warmth causes the air to expand and the bubbles to become dissipated; therefore any rise in the temperature of the water, such even as is caused by the impact between the stamps and the ore upon the die, is favorable to a diminution in the amount of slime.

When the pulp is discharged from the mortar-box it runs down copper plates covering long sloping tables. The copper, whether plain or silver-plated, is provided with an amalgamated surface, and it is this amalgamated surface which is supposed to do the work of arresting the gold. Mercury unites with gold, forming a heavy amalgam; but, in practice, it is found that a plate which is covered with a good coating of gold-amalgam will serve to arrest gold much more effectually than a clean surface of either amalgamated silver or copper.

The amalgamating tables have a slope varying with the amount of water used, the heaviness of the pulp, and the rapidity of the crushing. A gradient of seven-eighths inch per foot is common in Australia, while in Colorado the inclination is over two inches per foot. The colonial mills consume five gallons of water per stamp per minute, while those of Colorado use less than two gallons. Theoretically, the use of the least possible quantity of water, and the spreading of the pulp over the largest possible surface, will give the best separation of the gold from the gangue. In practice, the varying composition of the ore prevents a nice adjustment of the conditions. You may readily determine an inclination which will be most effective in causing a separation of the gold from the quartz, but it may be such as to cause the pyrite to settle. On the other hand, the slope may be so adjusted that the pyrite is carried away; but, such conditions may then be obtained as will also permit of the escape of the gold.

The amalgamating tables are attached to the frame-work of the mill. The vibration set up by the falling stamps causes a pulsation of the water flowing over the plates similar, in a way, to the action of a jig. This assists the work of gravitation. The vibration has, however, another effect, namely, that of crystallizing the iron of the working parts of the mill, making them brittle and decreasing their time of service. In this, as in other respects, the stamp-mill presents contradictory features.

At the outset, we described milling as the art of treating an ore so as to extract the maximum of value at the minimum of expense. Let us apply the description to the two types of mill to which particular reference has been made. In Colorado, a stamp crushes one ton of the ore of the Gilpin county mines in twenty-four hours, and the cost, using free water power, is seventy cents. In California, the best equipped large mills crush at the rate of rather more than two and a half tons at a cost, also using free water power, of about thirty-five cents per ton. The extraction in both regions will be, by amalgamation alone, about seventy per cent. We will omit the amount extracted by the concentration of any valuable pyrite, because the percentage of such material is very variable, and it forms a by-product, the value of which depends largely upon local conditions.

The ore of the Gilpin county mines carries about fifteen per cent. of pyrite, and other heavy sulphides. The gangue is more feldspathic than quartzose, and is the product of the alteration of the country rock—granitoid gneiss—and of the dikes which penetrate it. The gold is not only present in a state of very fine subdivision, but it is also intimately associated with the pyrite.

On the other hand, the mill-stuff treated in Amador, Calaveras and Tuolumne carries from one to two per cent. of pyrite. The gangue is quartz, but the ore also contains a very large proportion of the country rock, which in this case is slate, augite schist, and diabase. Of these, slate predominates. The gold is coarser than that of the Colorado ore, and it is not so closely associated with the pyrite.

Let us now consider the results to be obtained by an interchange of treatment, using California batteries on Colorado ore, and *vice versa*. The Gilpin county ore is of medium grade, say eight dwts., or $8 per ton. The local methods extract $5.60 at a cost of seventy cents. A California mill would give an extraction of only $4, but would crush such soft ore fully three times as fast, so that the cost would be, say twenty-five cents, giving a net yield of $3.75 as against $4.90 obtained by the methods of the district. Here, the slower mill gives the best results with a particular ore, and the Colorado mill-man considers the Californian very stupid because he does not use Colorado methods. Let us go to California and use the Gilpin county mill upon an ore of similar character and of lower tenor. We will consider the treatment of an ore containing six dwts., or worth $6 per ton. The California mill would extract seventy per cent. at a cost of thirty-five cents, leaving a balance of $3.95 per ton. The Colorado battery would extract an increased percentage, say seventy-five per cent., but the ore being much harder than that of Gilpin county, the crushing capacity would be less and the cost per ton greater than when treating Gilpin county ore, say, therefore, $1.00 per ton, leaving a net yield of $3.50 per ton. The California mill, if crushing 100 tons of ore per day, would, therefore, show a profit of $45 per day greater than when treating Gilpin county ore, say, therefore, $1.00 per ton, leaving a net yield of $3.50 per ton. The California mill, if crushing 100 tons of ore per day, would, therefore, show a profit $45 per day greater than that of the Colorado mill. As a matter of fact, there are other practical considerations which would render inadvisable the interchange of methods, among which may be mentioned the smaller size of the ore-bodies of Gilpin as compared to those of California, while it must also be remembered that the construction of a Colorado mill of a capacity equal to that of a California plant would require twice as much capital.

The comparison just made will serve as an illustration of the fact that milling is a business for getting money, and not a scientific pursuit directed to the obtaining of a perfect metallurgical treatment.

The contrasts between the methods in use in two mining districts in the same country, illustrates the first axiom of all successful ore-reduction, namely, that the treatment must be suited to the character of the ore. Colorado methods in California would probably fail just as surely as California ways have been unsuccessful in Gilpin county. This is a truism not always remembered by machinery firms, who do not desire to be bothered by the making of new patterns. Too often, the ore is required to bend to a certain treatment in a mill of a particular design, instead of the mill being modified to suit the necessities of a particular ore.

The stamp-mill has presented to us many contradictory features. It is seen to be compounded of good and ill. It may be simple, but it is clumsy ; it may be crude, but it is effective. As a machine, it has undergone an evolution common to all human inventions. It was founded on the first stone implement of the prehistoric savage ; it became modified into the *matate* of the Mexican and the tilt-hammer of the Chinese ; it progressed until running water was called in to aid human muscle, and in the machine of the Hungarian peasant, it reached the primitive type from which our present mills were evolved. How great has been the comparatively recent improvement can be seen by stepping from Hungary to California.

In the valleys around Verospotak, in Transylvania, the larger mills* consist of twelve stamps, in coffers holding four each. The power is derived from an overshot water-wheel ten feet in diameter. The cam-shaft is of iron, and revolves on agate bearings, lubricated with water. The lifter, or cam, is iron-shod. The stamp weighs 250 pounds, and has an agate head. The stem, the coffer, and all the rest, are made of beechwood. Each stamp drops thirty times per minute, and crushes about 300 pounds of soft ore per twenty-four hours. These machines have changed but little since the time of the Roman occupation under Trajan, when this district was a part of the province of Dacia. Well-preserved gold coins of the time of Trajan have been found in the mine-dumps.

Let us now go to California, whose record is little more than the record of a generation. Among the foothills of the Sierra Nevada we find mills containing eighty stamps, weighing 750 to 850 pounds each, and dropping ninety-five times per minute. Those of the working parts which are not of iron are made of steel. At single mills, 200 tons of ore are crushed per day. The mill building has a height of seventy feet, and the ore is never touched by manual labor from the moment that it arrives at the top in the mine-cars to the time when it is discharged at the bottom as waste.

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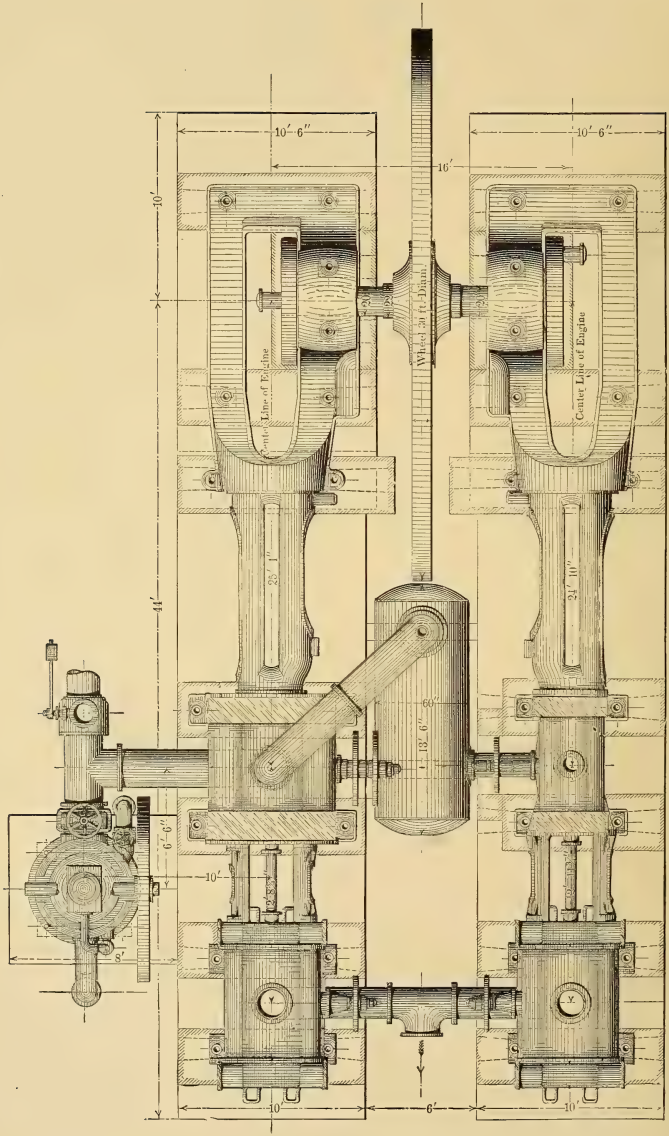
*Modern American mills have been lately introduced, and can be seen working side by side with those dating back to 100 A.D. For the particulars above given, I am indebted to Mr. E. H. Liveing.

In Transylvania, the individual shareholder often has his own mill; in California a thousand unite to operate one, which can, in twenty-four hours, treat as much ore as the Hungarian mill crushes in 100 days. The little machine of the Hungarian has been tapping away like a woodpecker for eighteen centuries, and yet has not produced as much gold as has been contributed in the brief time of one generation by that completer mechanism whose muffled thunder echoes among the cañons of California.

What has been done may serve as a measure of what can yet be done. Perfection is as unattainable in milling as in any other branch of industrial art; otherwise progress were soon ended. We can compare the old mill with the new, not only with a complacent satisfaction at the advance that has been made, but with the consciousness that where so much improvement was possible much room for improvement must remain.

It is not for me to attempt to foretell what place the stamp-mill is destined to hold in the metallurgy of the future. Let me, however, in concluding, suggest the reflection that though the appliances of to-day may show a great advance upon the older, more imperfect type from which they were evolved, yet there is no mining district that possesses a mill which cannot, in some essential, be improved upon.



BESSEMER BLOWING-ENGINE.—FIG. I.—PLAN. 40 x 78 x 60-INCH STEAM CYLINDERS AND 60 x 60-INCH AIR CYLINDERS.

BLOWING-ENGINES.*

By Julian Kennedy, Mem. Am. Inst. M. E.

THE different types of blowing-engines in use are so numerous that it would not be practicable to consider them all in this paper. I shall therefore only take up briefly a few well known types. The style of blowing-engine most largely used in this country is the vertical engine with air-cylinder above, cross-head between steam and air-cylinders, and two fly-wheels, each having a wrist-pin in its hub, or in one arm. This kind of engine can be built cheaply, takes up little room and is very accessible. Its disadvantages are that the cross-head is liable to break, and that putting the wrist-pins in the wheels tends to set up vibrations in them. It is likely that on the whole this type of engine will continue to be built quite extensively. The same general arrangement has also been used to some extent, but not widely, in horizontal engines.

The Bethlehem Iron Company have some very fine blowing-engines of this type except that they are compound, having the one steam-cylinder replaced by two side by side. These engines are noticeable not only for the very excellent workmanship on them, but also on account of the weight of the pistons being carried by steam pressure applied in chambers in the lower side, the steam being supplied to these chambers through the hollow piston rods. This arrangement, I believe, has always worked well. Another type of engine which has given good satisfaction is the vertical double-engine, having air-cylinders above, steam-cylinders below them, and cranks at bottom, the engines being coupled to cranks on the ends of the shaft, placed at right angles to each other, the shaft carrying the fly-wheel at its centre. Engines of this type, except that they are arranged horizontally, are also used to a considerable extent. These engines avoid the disadvantage of having wrist-pins in the fly-wheels and also dispense with the long cross-head with its attendant disadvantages. They give a very uniform pressure of blast and are very convenient for starting. The vertical engines of this type, as compared with the horizontal, take up less room and the wear on cylinders, due to carrying the weight of pistons, is avoided. On the other hand, the machine is very high and there is considerable vibration. The horizontal machine avoids this, is very accessible and is cheaper to construct. With proper attention there seems to be no serious trouble with wearing of cylinders, so that wherever ground-room is ample, the horizontal double-coupled engine seems to be very suitable. The principal objection urged against this style of engine is that in the event of a break a large machine is disabled, whereas, if two single engines are used, one can keep the works going while the other is being repaired. This is doubtless correct but I think that too much weight is often given to this consideration. With machines strongly proportioned and carefully built, there should be very few stops ; on the other hand, in the case of Bessemer engines, which are starting and stopping at short intervals, the fact that one attendant can handle the double machine is worthy of

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* A paper presented at the International Engineering Congress at Chicago.

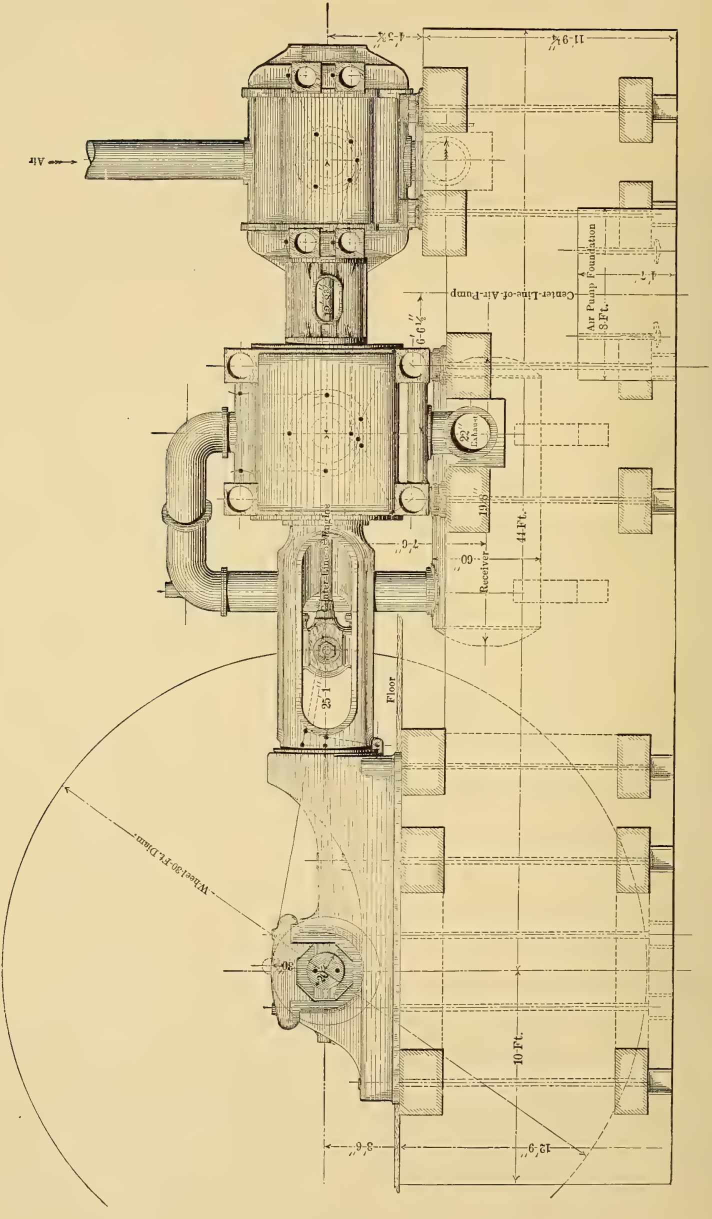


FIG. 2.—ELEVATION OF BESSEMER BLOWING-ENGINE.

consideration. The double-coupled type of engine is also particularly adapted to compounding. As most blowing-engines run under a comparatively constant load, and as the increasing use of water tube boilers in iron and steel works renders it easy to maintain high steam pressures, I have no doubt that before long compound blowing-engines will be adopted in a large majority of the new plants built.

In looking over the different kinds of blowing-engines, we cannot fail to be impressed with the fact that in nearly every case, the air-valves are the weak point in the machine. In the great majority of cases the maximum speed of the engine is about half what it could be, if the air-valves could work fast enough. To remedy this fault, several plans have been resorted to. In some cases fairly good results have been obtained by making the valves very light, giving them but little lift, and arranging them so that they shall seat by gravity. In some cases valves of this kind are so constructed that the air in entering the cylinder is compelled to pass through a large number of very small openings. This is a very objectionable arrangement, not only on account of the increased amount of friction, but because the air in passing over the metal grids in thin streams will absorb quite a considerable amount of heat from the heads, which, in the case of engines working against high blast pressures, are made very hot by the heat of compression.

This heating of the incoming air expands it and proportionally reduces the weight of air entering the cylinder at each stroke. I have observed this in the case of an engine, which was so constructed as to cause the air to travel about three inches over the hot metal in thin films of about three-sixteenths of an inch thick. Alongside of it was another engine of same size and make, except that valves were used which allowed the air to pass over about one inch of metal, the openings being of such size that each stream of air was two inches in thickness. Careful and repeated tests of these engines, when both were in good order, showed that while the indicator diagrams were practically the same, the one with the large valves would burn about ten per cent. more coke in the furnace, a result which could only be explained on the supposition that in the case of the engine with small air-openings, the incoming air in passing through the small and tortuous passages in the heads was heated about twenty-five degrees Centigrade more than in the case of the other engine. It is plain, therefore, that a blowing-engine should have air-valves, which will not only give ample area of inlet passage, but give this in a small number of good-sized openings.

Figs. 1 and 2 are the plan and elevation, and Fig. 3 is the diagram of air-valves and valve-gear of a compound horizontal blowing-engine, now being constructed by the well-known builders, the E. P. Allis Company, for the Ohio Steel Company. The engine is a Reynolds-Corliss cross-compound ; steam cylinders, forty inches by seventy-eight inches ; air cylinders, sixty inches ; stroke, sixty inches, with reheater in intermediate receiver, and is provided with an independent condenser. In general design this engine, as will be seen at a glance, is very similar to the large quadruple-expansion engine by the same builders shown at the Chicago Exposition. The air cylinders are so arranged as to draw the air through pipes which project above the roof of the building and to discharge it below the cylinders.

The inlet-valve is a plain rotary valve held to its seat by the blast pressure, which is admitted to the back of the valve by a port from the discharge-chamber, and is driven from a wrist-plate. The outlet-valve, as will be noticed, is a triple-ported valve, which is closed at the proper time by the wrist-plate.

The connection between the wrist-plate and valve is made by a teloscopic extensible rod, which pushes the valve shut but permits the wrist-plate to reverse its motion without pulling the valve open. To the valve lever is attached a vacuum-pot, which tends

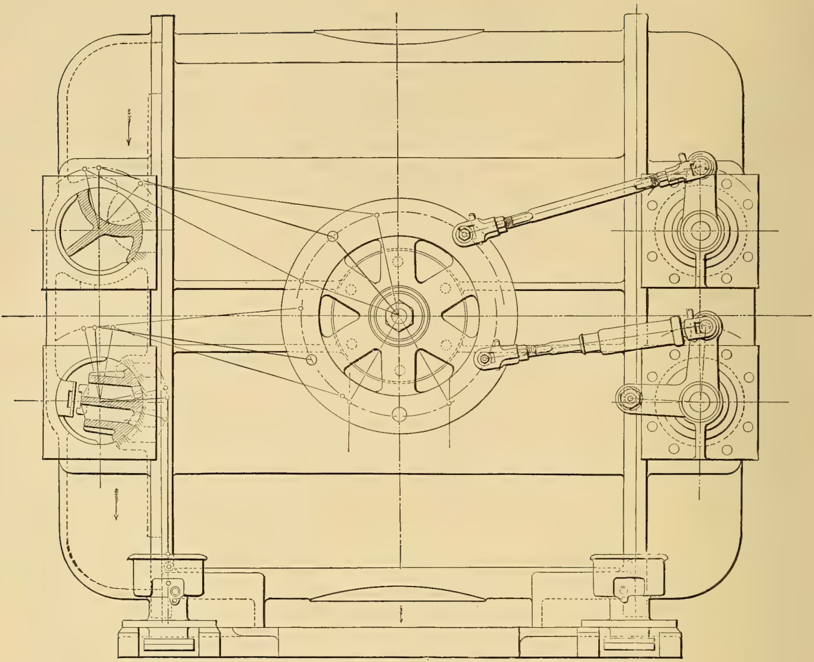


FIG. 3.—ELEVATION OF AIR-CYLINDER AND VALVE GEAR.

to pull the valve open. When the valve has been closed it is gripped by the receiver pressure acting on the back, holding it against the seat, and remains stationary during the return stroke of the piston, and also while the piston advances towards it again, until it has compressed the air in the cylinder to nearly the same pressure as that in the receiver, at which time the pressure on the back of the valve becomes so nearly balanced that the vacuum-pot can move the valve, which is then quickly thrown open. The telescopic connecting-rod is so constructed that a small dash-pot is formed at the bottom of the tube to avoid shock should the plunger strike the bottom while the valve is open or when the closing motion begins. It will be observed that no trip or releasing gear of any kind is used with these valves, the holding and releasing being done by friction controlled in the simplest possible manner by the air-pressure in the receiver and cylinder. The outlet-valves are also held against their seats by long flat springs bearing in the centre on the back of the valve and at ends on blocks set in pockets at end of the valve. It will be seen from the drawings that these blocks have a clearance of one-half inch at the bottom, so that if for any cause the valve should be prevented from opening at the proper time it will be only forced back from the seat, the opening of one-half inch being sufficient to allow the engine to run at full speed with wrist-plate and vacuum-pot disconnected from outlet-valves. This valve-gear is extremely simple, and practical tests have shown it to work admirably. This engine is intended to run at a speed of sixty turns per minute if necessary.

In conclusion, the tendency in designing blowing-engines seems to be in the following directions :

First. Compounding.

Second. Obtaining valve-gear which will give liberal openings at both inlet and outlet, and which can be operated at a fairly rapid speed.

The latter advantage can probably be best secured by the use of metal valves operated as far as possible positively, which will also do away with the vexation due to the use of leather, gum and other short-lived materials.

SOME LEGAL ASPECTS OF RAILROADING.

By Wm. Arch. McClean.

IN the course of time, along with the development of railroads and railroading, have come many apparently conflicting legal decisions as to the duties and responsibilities of railroads and their employees to each other. In time, certain fixed principles became recognized and established, the following being gleanings of such principles from latest decisions. They may be said to be as legally correct in their application to all branches of engineering as to railroading.

In the first place, a railroad company owes to every employee the duty of providing a reasonably safe place in which to work, and reasonably safe instruments, tools and machinery to work with. As a matter of course follows the duty of exercising reasonable care in regularly inspecting cars, brakes and other appliances used by their employees, so as to ascertain if such appliances are in a suitable and safe condition, and to remedy any defects that may be discovered. The diligence of the company is to be in proportion to the hazard of the service.

In a late case, a railroad brakeman, in assisting to shift a train jumped upon a car just as the train was about to move and proceeded to perform his duties. While so engaged he fell on the track, was run over and killed. It appeared that the brake on the car was defective and dangerous and had been negligently permitted to remain so by the company. The defect was discoverable upon the attempt to use the brake, and the brakeman had only two or three minutes to become acquainted with its character and condition. It appeared that he never seen the car or brake before the time of the accident, and whatever knowledge he had of it must have been acquired during the brief period that he was on the car before he fell off. He was seen to pull on the brake wheel just before his fall. Such a fall could easily result from the slipping of the wheel in an attempt to work the brake, and the verdict of the jury, sustained by courts, was that the defect in the brake was the cause of the brakeman's fall and that the railroad was negligent in not providing a reasonably safe brake on the car.

Railroad companies are not responsible for every accident that happens to employees. The latter take upon themselves the natural and ordinary risks incident to the performance of their services. By contracting for the performance of hazardous duties they assume such risks as are incident to their discharge from causes open and obvious, the dangerous character of which they have had opportunity to ascertain. No more apt illustration of this proposition can be found than in the repeated failure of suits for damages for the killing of brakemen by being knocked off the tops of cars by low bridges. The courts have uniformly held that railroad companies do not owe it as a duty to their employees to maintain bridges high enough for an employee to pass under while standing on top of a box car. Brakemen contract for the performance of hazardous duties. They learn about the road and bridges, and must look out for the latter. If they are caught, it is their own fault according to the law.

A railroad company is bound to keep, maintain and repair the machinery so as to be reasonably and adequately safe to be upon and to use. The boiler of an engine had been condemned as unfit for use and was ordered into the shops for the purposes of repairs. When supposed to have been made safe, it was ordered out and placed in the hands of its engineer and fireman. It blew up and killed both. It was shown to have been insufficiently repaired and the company was held responsible for negligence in repairing. In this case the repair work was done by fellow servants of the engineer and fireman in the employ of the company and the latter sought to escape liability on that ground. The court held, however, that the duties of corporations must be performed by agents, and that the default of such agent is the default of the corporation and not of a fellow servant.

It is not enough for an employee to prove an injury to recover damages from a railroad company. Employees are not in the same category with passengers who have paid for a safe trip. An employee, to recover damages, must prove not only the negligence of the employer, but also that this negligence was the cause of his injury. The ground of an employer's liability for injuries received by an employee while operating machinery is not danger, but negligence, and the employee must show that the injury was caused by such negligence. The test of negligence is the ordinary usage of the business. Where the evidence discloses no such negligence of the employer, from which the injuries resulted, the plaintiff is turned out of court by a non-suit, as illustrated in the following cases:

A locomotive engineer, at about five o'clock on a December morning, while it was still dark, was seen upon the seat at the right side of the locomotive cab while the train was going west. When next seen, he was lying on the floor of the cab on his back, face upward, with his head near the feet of the fireman and his skull fractured. The accident occurred near the east end of a siding. At this siding, the evening before, there was a box car, some two hundred and seventy-five feet from the switch. On the following morning this car was near the switch. At the east end of the car, the rails of the side track were four feet eight inches from the rails of the main track. There was no evidence to show how the car came to be in this position. The tracks were nearly level. The engineer in leaning out of the cab window, came in violent contact with the box car with the result above stated. The engineer, it was maintained, was acquainted with the danger of his employment, with the road, sidings and switches and the company could not be held for the accident which was interpreted as occurring in the ordinary usage of the business.

In another case a company was charged with negligence by reason of the use of a particular, broad-gauge car body upon a narrow-gauge truck not adapted to it. A brakeman had been on the train five or six months, during which time this method of carrying broad gauge cars had been followed. Cars similar to the one on which the accident occurred had been frequently carried and the brakeman had ample opportunity to know the risks of such trains. The court, therefore, believed it to be a plain case of acceptance of an employment with full knowledge of the risks. When the train was passing a curve, the car was observed to sway from side to side and afterward to bounce as if off the rails. The brakeman had been sitting on the brake wheel on the top of the car at its rear end. When the car commenced to rock he started to run along the top to get to the car in front, but before he could get that far, the car tipped over. The brakeman jumped to one side and, falling on the track, was killed. The court held that because a particular method or appliance is dangerous, it does not follow that it is negligence for an employer to use it. The test of negligence in methods, machinery and appliances is the ordinary usage of the business, and carrying broad gauge cars in this way was such an ordinary, though hazardous, usage.

The employee must not only exercise ordinary care in the discharge of his duties, but when an accident occurs by reason of the negligence of the company there must not appear the slightest contributory negligence on the part of the employee, or there will be a failure to recover damages. The contributory negligence which prevents recovery for an injury must be such as co-operates in causing the injury and without which the injury would not have happened. The test is found in the question: Did the plaintiff's negligence directly contribute in any degree to the production of the injury complained of? If it did, there can be no recovery. If it did not, it is not to be considered. Whether or not there has been contributory negligence, is to be gathered from the testimony of the plaintiff and his witnesses. If contributory negligence appears, a non-suit inevitably follows. If there is some doubt or dispute about the alleged contributory negligence, the question of its existence is left to the determination of the jury. If the jury finds that there is any contributory negligence, their verdict must be against the plaintiff.

Certain things are declared to constitute negligence in themselves, such as putting an arm out of the window, or riding in places on trains that are forbidden, or the riding of an employee on the pilot of an engine when he could have ridden elsewhere. A brakeman was directed to take a train of platform cars, loaded with lumber and pushed by an engine in the rear, up to some other cars on a siding three hundred yards distant, the siding being straight and up grade. He put his left foot into the iron stirrup at the right hand side of the front end of the front car, his right foot on the bumper and one of his arms over the side of the box of the car to hold himself on and rode in that position until the front car became derailed by reason of a rotten tie. The front end of the car, veering over to the right, the man was caught between a board pile and the car and so injured that he died. This board pile was one of a series quite close together, and not over forty inches from the side of the car. It was held that the position of the brakeman did not show contributory negligence. He was riding as he had often done before, and as he had seen others do repeatedly. There was abundant room between him and the lumber piles. He certainly was not bound to anticipate that the cars would become derailed just at that point, and that as the result thereof he would be crushed and killed between the car and piles of lumber.

An interesting case is the following, in which it was earnestly contended that the failure to comply strictly with a rule of the railroad would be such contributory negligence in itself as to bar recovery. The court refused to adopt such a ruling and sustained a verdict in favor of the plaintiff—a conductor's widow. The conductor of a freight train was subject to a rule of the company which directed him to take his position in about the middle of the train when it was going down grade, so as to be able to properly direct the brakeman. Just as the train started down a slight grade, about a mile in length, the conductor went forward to the engine and told the engineer "to run slow and look out for the Iron Company's engines, they are liable to come outside their limits." The train was running at the time under a special order to look out for an iron company's engines at a point some distance beyond. While the conductor was giving this direction to the engineer and receiving his answer, the engine and some of the cars were thrown from the track owing to a defect in the roadbed, and the conductor was killed. If he had remained in the middle of the train he would probably have been uninjured. The conductor was held not to be guilty of contributory negligence. While a conductor should be held to a reasonable observance of rules, still he has a general duty and discretion to use his judgment for the safety of his train in case of an emergency. If there was any probability of an obstruction, not known to the company, it was the conductor's duty to guard against it, and he was entitled to walk to the engine for that purpose. It has been lately said that the rule sometimes laid down that the plaintiff must present a case clear of contributory negligence was never intended to mean that the plaintiff, after proving affirmatively that the defendant's negligence caused the injury, must also prove negatively that he himself was not guilty of negligence that contributed to the result. The obvious meaning of that and similar forms of expression is that the burden is on the plaintiff to prove that the injury complained of was caused by defendant's negligence; and if, in doing this, the fact is disclosed that his own negligence contributed to the result, there can be no recovery, because the case as then presented by the plaintiff is not clear of contributory negligence.

FROM MINE TO FURNACE.

By John Birkinbine, Pres. Eng. Club of Phila.; Past Pres. Am. Inst. M. E.

Fifth Paper.

THE blast furnace (a structure either built of stone masonry or excavated out of the solid rock), about 30 feet high, having a bosh of 7 or 8 feet in diameter, had grown in 1866 to a more pretentious structure, where a height of 60 feet and a bosh diameter of 16 to 17 feet was attained, but in a majority of cases, the masonry structure was maintained, although brick displaced the stone to some extent, and the boilers and hot blast stoves were often erected upon heavy and expensive arches or carried on side hills supported by massive retaining walls, to facilitate diverting tunnel head gases to them. The output of twenty to thirty tons per week had grown to 150 or 200 tons in 1866.

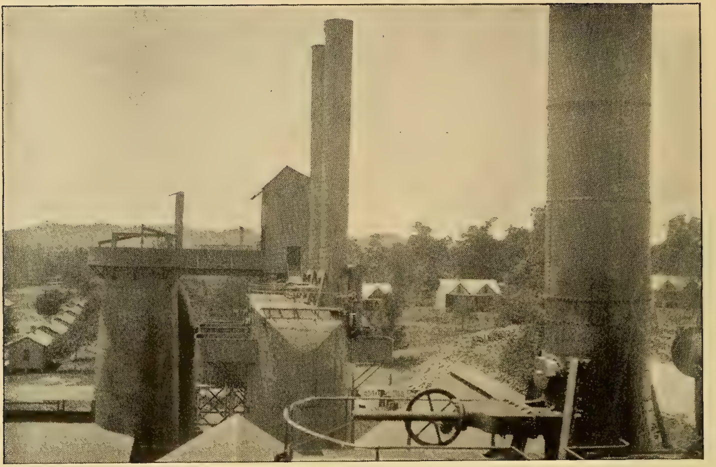
The blast furnace of to-day, producing five times the amount of iron, costs little more than the furnace of twenty-five years ago, and is a more convenient, more shapely and a better equipped plant.

Probably no better illustration of the development of the blast furnace can be offered than the following memoranda concerning the largest plant in Pennsylvania, viz., that of the Edgar Thomson Steel Works, consisting of nine blast furnaces, which can produce together over 2000 tons of pig-iron daily, and which have averaged a total output of between 1500 and 1600 tons per day. One of these furnaces, which completed thirty-seven months of its present blast in April, 1893, had made in that time 370,000 tons of metal, and was running at the rate of 11,000 tons per month. The furnaces are 80 feet high with boshes 20 feet, 22 feet and 23 feet in diameter, and 90 feet high with boshes 22 feet in diameter. Thirty large blowing engines supply blast for this group of furnaces. One hundred and twenty boilers furnish steam to drive the blowing engines, the pumps and hoisting appliances, and twenty-four pumps are in constant use, furnishing water. Thirty-three hot blast stoves heat the air supplied.

One of these furnaces has reached the remarkable output, for a single day, of 623 gross tons of iron; in a week one furnace stack has made 3203 gross tons, and in a month one stack produced 12,800 gross tons; that is, in one month, one of these furnaces produced fully as much iron as twenty-five years ago would have been turned out in a year from the best and largest of the American blast furnaces. This is not due alone to the equipment nor even to the equipment and management, unless in the management is included the appreciation by the owners of the value of using richer ores and of paying for the preparation of the ore used, so as to increase the percentage of iron.

Notwithstanding the new plants added, the active list of 1892 numbers five less than that of 1891. The increased output of pig-iron is due to larger average dimensions of the furnaces, better equipment and improved management.

By reference to the table of the total number of furnaces, and those in blast



VIEW FROM A FURNACE TUNNEL HEAD.

at the close of various years (see Table A), it is evident that the largest number of furnaces in any year was in 1877 and 1881, when 716 were on the active list. Since that time there has been a gradual decrease in the number, owing to the older and smaller furnaces which had no possible future, dropping out. The largest number in blast at one time was in 1881, when there were 455 ; the smallest number was in 1876 and 1884, when 236 only were in operation.

It is difficult in many instances to determine which of the blast furnace plants of the country should or should not be considered as upon the active list. A number have not been in operation for years and although still reported as active, will scarcely be put in blast again, and others are handicapped so that they can only operate in times of abnormal profits. It is therefore scarcely probable that there are over 550 blast furnaces in the United States which can properly be considered as active ; so many considerations affect the various plants, that it is quite impossible to determine the exact number. Those figures have been taken from reports presented by the American Iron and Steel Association, which are recognized as being most reliable.

In a paper presented before the American Institute of Mining Engineers, in February, 1887, detailing the distribution and proportion of American blast furnaces, the writer showed that 205 coke furnaces varied, in height, from 42 feet to 86 feet, and in bosh diameter, from 9 feet to 22 feet. The average size of all furnaces using bituminous coal or coke was 64 feet high and 15 feet 6 inches bosh diameter, with a nominal annual capacity of 24,700 gross tons each.

Similarly 203 furnaces using anthracite coal or anthracite and coke mixed varied in height from 30 to 81 feet, and in bosh diameter from 8 to 20 feet 6 inches, averaging 57 feet 1 inch high, and 14 feet 8 inches bosh, with a nominal annual capacity of 14,400 gross tons each.

In 171 charcoal blast furnaces the heights ranged between 25 and 62 feet ; and the bosh diameter, between 7 and 13 feet, the average dimensions being 41 feet by 9 feet 7 inches, and the average nominal capacity, 6000 gross tons.

Similar data collected for the present time would show a slight increase in the maxima, and a considerable change in the minima, by reason of a number of small plants being abandoned or replaced by others of greater dimensions. There is therefore now a considerable increase in the average dimensions and nominal annual capacity of American blast furnaces over the figures of 1887.

We have no reason to anticipate a serious break in our growth in population, and as we increase in numbers, more iron will be necessary. If our general prosperity continues, the augmented wealth of the nation should encourage a greater production of pig-iron per capita, for a considerable portion of our country is inadequately supplied with transportation facilities. The extension of railroads will build up new towns, towns will grow into cities, each commanding an increase in the pig-iron product, both for railway connections and local requirements.

At the present time there is a general severe depression in the iron trade. Mines and blast furnaces are idle, and the rate of pig-iron production is now less than one-half of what it was a year ago. Much of this decline is traceable to uncertainty as to further values, and although the extreme depression will probably be but temporary, a general resumption of activity cannot be expected until a governmental policy concerning duties on foreign iron ores, pig and manufactured iron, and of steel is definitely determined. If radical changes are made the trade must adapt itself to the altered conditions.

The question of import duties has been a partisan issue, too often considered with reference only to local conditions; it is a national issue which must be met in its relation to the whole country. There is at present a duty of seventy-five cents per gross ton on all iron ore imported into the United States, and the following statement shows that, notwithstanding this charge, the quantities imported have reached figures of importance.

Years.	Gross tons.	Years.	Gross tons.
1879	284,141	1886	1,039,433
1880	493,408	1887	1,194,301
1881	782,887	1888	587,470
1882	589,655	1889	853,573
1883	490,875	1890	1,246,830
1884	487,820	1891	912,864
1885	390,786	1892	806,585

An inquiry into the operation of the iron ore mining operation of the country demonstrates that very few mines have been worked in late years which have not some marked advantage, either in location and transportation facilities, cheap mining or excellence of product. Numerous mines which were formerly worked have been idle for years, not because of their exhaustion, but because mining on a limited scale, or expensive handling, costly transport, or inferior quality precludes the possibility of competing with other mines possessing greater advantages. Under these conditions it does not seem that the duty laid upon iron ore is more than sufficient to equalize the cost of labor in this and foreign lands, while the specific duty has a tendency to bring to our furnaces the best that the world produces. Further evidence is found in the fact that domestic ores have been transported by rail and water, with several handlings, for from 1000 to 1200 miles, and yet have competed in price with foreign ores within fifty miles of the seaboard.

The statement concerning iron mines can be practically repeated for blast furnaces. There are very few which have been active in late years that do not possess superior advantages, and the competition among these has been so sharp that the total stocks in maker's hands held for sale, have seldom exceeded the quantities similarly held from fifteen to twenty years ago, notwithstanding the great increase in production. This is remarkable when the difficulties of stopping or starting a blast furnace are considered. Stocks of raw materials must be secured to start, or must be reduced to suspend operation. To blow out and reline a stack is expensive and the maintenance of, or collecting an operating force is costly. Notwithstanding these drawbacks the susceptibility of the American blast furnaces to market considerations is emphasized in the following table, which shows the relation that domestic production has borne to stocks held for sale, and to foreign pig-iron brought to the United States:—

Production, Stocks, and Importations of Pig-iron.

Years.	Stock of pig-iron, gross tons.	Importations, gross tons.	Domestic production, gross tons.
1874,	710,521	54,612	2,401,262
1875,	679,382	59,337	2,023,733
1876,	613,213	74,171	1,868,961
1877,	573,528	59,706	2,066,594
1878,	513,004	66,503	2,301,215
1879,	126,495	304,171	2,741,853
1880,	407,730	700,864	3,835,191
1881,	188,300	464,430	4,144,254
1882,	383,655	540,159	4,623,323
1883,	476,607	322,648	4,595,510
1884,	529,464	184,269	4 097,868
1885,	371,886	146,740	4,044,526
1886,	225,629	361,768	5,683,325
1887,	301,913	467,522	6,417,148
1888,	300,144	197,237	6,489,738
1889,	247,679	142,230	7,603,642
1890,	608,921	134,955	9,202,703
1891,	596,333	67,179	8,279,870
1892,	506,116	70,125	9,157,000

THE FUTURE.

The development of the pig-iron industry, as indicated by census returns for the years 1870, 1880 and 1890, is as follows: 9,579,779 net tons are reported by Dr. Wm. M. Sweet, special agent in charge of the iron statistics for the eleventh census, as the output for the United States for the year ending June 30, 1890.* This is equivalent to 8,553,374 gross tons. It shows that from 1880 to 1890, the production of pig-iron increased 153 per cent., while from 1870 to 1880 the production was augmented eighty-five per cent. The general distribution of this production in the three census years, 1870, 1880 and 1890, is exhibited by Table C.

TABLE C.—Production of Pig-Iron in the United States according to Census Returns.

Districts.	Tons of 2000 Lbs. Year Ended May 31, 1870.	 Year Ended May 31, 1880.	 Year Ended June 30, 1890
New England States	34,471	30,957	33,781
Middle States	1,311,649	2,401,093	5,216,591
Southern States	184,540	350,436	1,780,909
Western States	522,161	995,335	2,522,351
Far Western States	——	3,200	26,147
Total..................................	2,052,821	3,781,021	9,579,779

These figures suggest the query, "what will be the future of the pig-iron industry in the United States?" Will this development continue in the same ratio? that is, will the next twenty-five years show as marked growth, or what will that growth be relatively to the twenty-five years past? It has been shown that the output of 1890 was seven and five-eighths times that of 1866, and that to make the same advance in the next one-quarter of a century, would demand a production in 1915 of over 70,000,000 gross tons of pig-iron. This we do not expect to attain. In the last two decades, our pig-iron output has increased over five and one-half times, and this rate would make the production in 1910, less than two decades hence, exceed 50,000,000 gross tons. Neither is it presumed that we will reach this figure. In the last decade, we have augmented the output nearly two and one-half times; a similar increase in the coming decade would make the production of pig-iron in 1900, 22,000,000 gross tons, which would also represent a large rate of increase. It must be remembered that a portion of the later development has been abnormal, and is not to be credited to augmented consumption. Some of the increased production of pig-iron is due to the restrictions of importation, which cannot be removed, unless by legislation, which would greatly damage the industry; and lately, consider-

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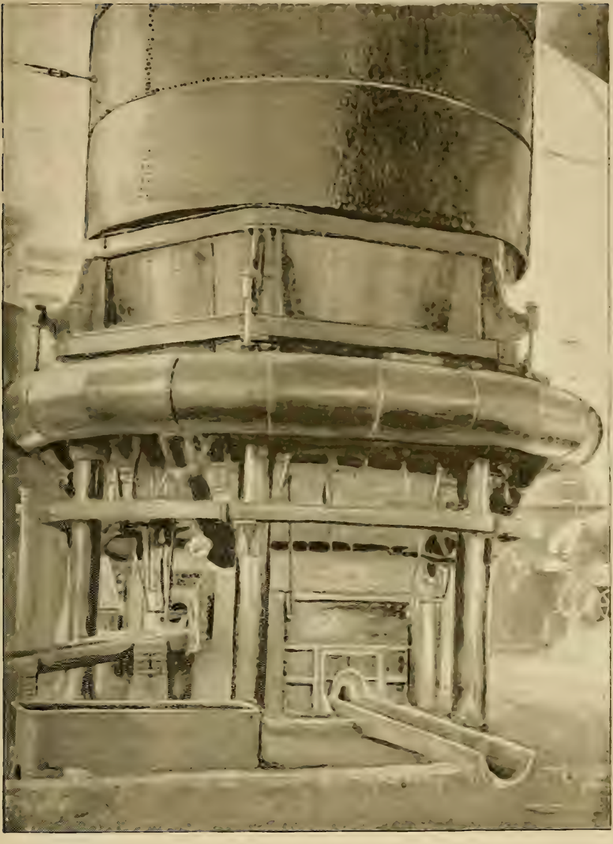
*The apparent discrepancy between the figures of Messrs. Swank and Sweet is due to the different intervals covered by their reports.



A BLAST FURNACE CRUCIBLE.

able development has been associated with real estate speculative schemes, which will be apt to exert a restricting influence in the near future. But while it is not probable that either of the figures above mentioned will be reached in the intervals of time indicated, if political action does not disturb the industry, or if labor troubles do not seriously interfere with developments, there seems no reason for expecting that the pig-iron industry will remain dormant, but we may rather look for a nearly steady growth which, at the expiration of twenty-five years, will probably make the annual requirements of the United States, in pig-iron or its equivalent, amount to between 20,000,000 and 25,000,000 gross tons.

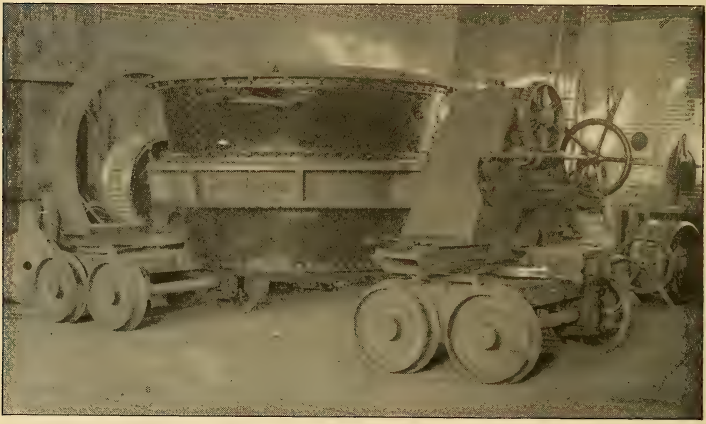
Fortunately, we can only surmise as to the future, but the above figures are the result of a careful study of statistics, taken in connection with an intimate knowledge of the present state of development and a personal acquaintance with the possibilities of various portions of the country. There will be times of depression like the present preceded and followed by others of unusual activity, but we may confidently look forward to a material advancement, perhaps greater than estimated, but certainly much more pronounced than was believed possible ten years ago.

The following remarks concerning the progress of the pig-iron industry and a prophecy as to its future appear in volume xv of the Tenth Census, namely, that of 1880, which is presented here to show how much more rapidly the industry has developed than was then anticipated would be the case eight years ago, when it was written.

"In 1866 the United States had reached the production of Great Britain in 1835; that is to say, she was then thirty-one years behind the latter country. At the end of 1884 she was but twenty-one years behind England. And at the same rate of increase for both countries, the United States will be but fifteen years behind England in 1900, and will reach and pass her in 1950, the production of pig-iron in each country for that year, as determined from the equation of their respective curves, being a little over 30,000,000 tons.

The facts are that in 1890 the United States passed and has since that time led Great Britain as a producer of pig-iron.

In a paper read at a meeting of the American Institute of Mining Engineers, in October, 1890, by its then President, Hon. Abram S. Hewitt, Table D (see opposite page) was presented, showing the comparative rate of increase in population and pig-iron production in the United States for six decades.



WEIMER'S TILTING LIQUID CINDER CAR.

This table, the writer says, "brings out the striking conclusion that the production of pig-iron has always increased more rapidly than the population and that the ratio is an increasing one. Between 1830 and 1860, the production of iron increased twice as fast as the population. Between 1860 and 1890 it increased four times as rapidly, in reality over four times, thus proving that the national wealth continues to grow from decade to decade, at a rate of acceleration of which the world affords no previous example. Inasmuch as during all this time, we have imported iron in addition to our production, it follows that the consumption per capita has also increased more rapidly than population. In 1855, according to careful calculations, which I made at that time, we were consuming iron at the rate of 117 pounds per head; whereas, in 1890, the consumption has increased to rather more than 300 pounds per head, the whole of which, for the first time in our history, we are producing within our borders.

Great Britain, on the other hand, produces more iron than it consumes, and is still the largest per capita producer in the world. In 1889 with a production of 9,321,563 tons of 2000 pounds, and with a population estimated at 38,000,000, the production reached the large figure of 495 pounds per head. Deducting the exports, Great Britain is now consuming 250 pounds per head against a consumption of 144 pounds in 1855. But the production of iron in Great Britain appears to be now very nearly stationary.''

TABLE D.—Relative Increase of Population and Pig-Iron Production.

Year.	Production of Pig Iron, Gross Tons.	Rate of Increase Per Cent.	Population.	Rate of Increase.
1830	165,000	—	12,866,020	32.51
1840	315,000	91	17,069,453	33.52
1850	564,000	79	23,191,876	35.83
1860	821,223	46	31,443,321	35.11
1870	1,696,429	106	38,558,371	22.63
1880	3,835,191	126	50,155,783	30.08
1890	9,202,703	140	62,622,250	24.86

Mr. Hewitt anticipates fully as great development of the iron industry as the writer mentions, for he says: ''I think it is safe to estimate, therefore, that in 1900 the world will require 35,000,000 gross tons of iron, of which the United States must supply forty-five per cent., and the other iron-producing countries the remainder, in the proportion of half to Great Britain and half to Germany, France, Belgium and the other small producers.'' His prophecy means a production in the United States in the year 1900, of 15,750,000 gross tons.

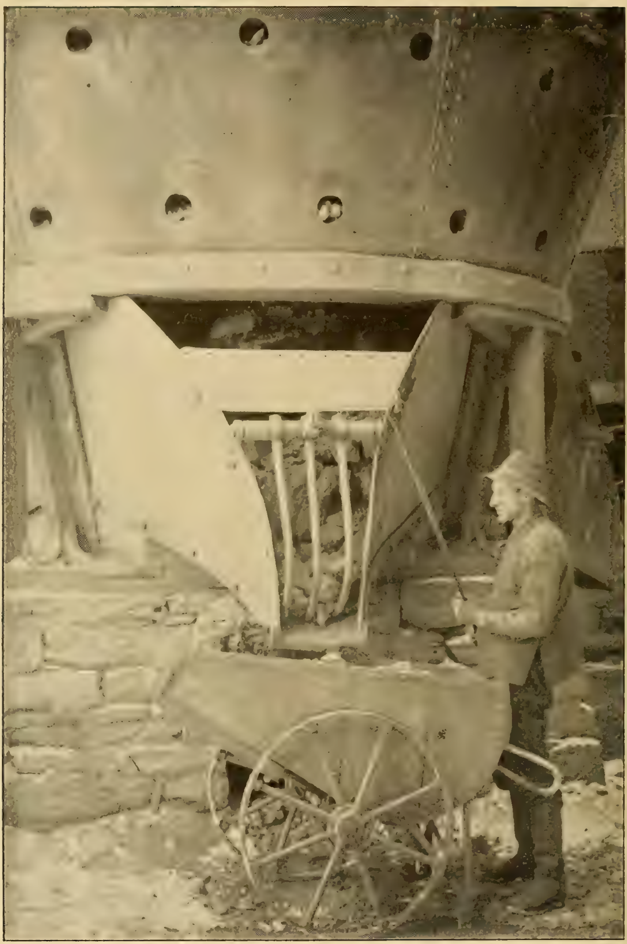
Mr. Edward Atkinson presents the following estimate concerning the prospective demand of the world for pig-iron in the year 1900:

	Tons.	Tons.
Present production..		25,000,000
Increased consumption in the United States............	7,000,000	
Increased consumption in Great Britain, France, Germany and Belgium,	2,000,000	
Increased consumption in all the rest of the world.......	6,000,000	
Total increase of demand,		15,000,000
Total supply required....		40,000,000

He says: ''If then one may predict a continuance of this law of accelerating demand for the next eleven years, neither 40,000,000 nor 44,000,000 gross tons will suffice in the year 1900. If this increasing demand should continue, the supply must be 100 per cent. in excess of that which now prevails. The supply in 1900 must be 50,000,000 gross tons or 56,000,000 net tons. Who will supply it?''

For the reason heretofore given, I do not place the future output at as high a figure as either of the gentlemen named, but at either of the rates of increase indicated, there is an apparently bright future before those engaged in pig-iron production, ore and coal mining, coking and other allied industries, who are in position to share in this growth, but every advance made must be with discretion and after a thorough investigation of existing and prospective competition.

The day has passed when iron can be successfully produced without improved



DRAWING ROASTED IRON ORE FROM A KILN AT A BLAST FURNACE.

appliances, both in construction and modern methods of operation. The blast furnace must supply what the consumer wants, and technical knowledge will keep close company with administrative ability in securing the increased output, to which all investigations point as a certainty.

Referring to the figures for 1860, 1870, 1880 and 1890 (see Table E), it will be interesting to consider the pig-iron production in the censuses named, and also the population of the country, to show what relations exist between population and production. Taking the figures presented, we find the following comparisons between the number of people and the tons of pig-iron made, in each of the census years, in the several sections of the country, and also in the State of Pennsylvania. Reference is especially made to Pennsylvania, because it has led, still leads, and will probably continue for some time to lead all other States as a producer of pig-iron.

TABLE E.—Distribution of Population and Production of Pig-Iron, According to Census Returns of 1860, 1870, 1880 and 1890.

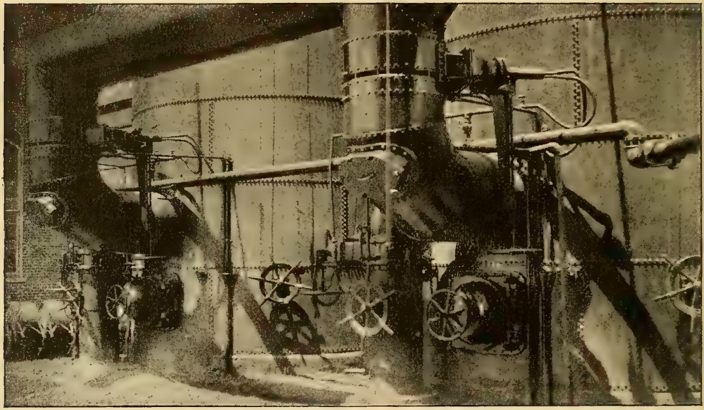
	1860.			1870.		
	Population.	Production of Pig-Iron.	Inhabitants per Ton of Pig-Iron.	Population.	Production of Pig-Iron.	Inhabitants per Ton of Pig-Iron.
United States	31,443,321	987,559	31.84	38,558,371	1,832,876	21.04
Pennsylvania	2,906,215 9.24	580,049 58.74	5.01	3,521,951 9.13	922,564 50.33	3.82
New England	3,135,283 9.97	26,600 2.69	117.87	3,487,924 9.05	30,778 1.68	113.33
Middle States	7,571,201 24.08	706,369 71.53	10.72	8,935,821 23.17	1,171,115 63.89	7.63
Southern States	9,981,480 31.74	100,761 10.20	99.06	10,859,955 28.16	164,768 8.99	65.91
Western States	10,755,357 34.21	153,829 15.58	69.92	15,274,671 39.62	466,215 25.44	32.76
	1880.			1890.		
United States	50,155,783	3,375,911	14.86	62,622,250	8,533,374	7.32
Pennsylvania	4,282,891 8.54	1,723,492 51.06	2.48	5,258,014 8.40	4,207,599 49.19	1.25
New England	4,010,529 8.	27,640 .82	145.10	4,700,745 7.51	30,162 .35	155.85
Middle States	10,643,486 21.22	2,143,833 63.50	4.96	12,869,293 20.55	4,657,670 54.45	2.76
Southern States	13,975,686 27.86	311,639 9.23	44.95	16,236,784 25.93	1,582,106 18.50	10.26
Western States	21,526,082 42.92	892,799 26.45	24.11	28,815,428 46.01	2,283,436 26.70	12.62

The census year 1860 shows a population of nearly 31,500,000, and a production of less than 1,000,000 tons of pig-iron; that is, we produce one ton of pig-iron for about every thirty-two inhabitants, but in 1870, while the population had increased about one-quarter, the production of pig-iron had been nearly doubled, and in that year one ton of pig-iron was produced for every twenty-one inhabitants. The census of 1880 shows a population of over 50,000,000, an increase of nearly one-third over 1870, and a production of pig-iron eighty per cent. greater than in 1870. In this year one ton of pig-iron was made for every fifteen inhabitants. The census of 1890 shows a population of over 62,500,000 and a production of over 8,500,000 gross tons of pig-iron. This demonstrates that in that year the United States produced one ton of pig-iron for every seven and one-third inhabitants. Assuming that the population has advanced according to the rate assumed by the Census Bureau, we will find that in 1892 there was produced one ton of pig-iron for every seven inhabitants, the production last year being slightly less than in 1890.

We may also investigate the distribution of the population and the pig-iron production, in each of the four general divisions, following the early method on account of using the census of 1860. These divisions will be New England States, as generally accepted, including Maine and intermediate States to, and including, Connecticut; the Middle States (New York, New Jersey, Pennsylvania and Delaware), the Southern States, all States south of the Ohio and Potomac rivers, and east of the Mississippi river, including Maryland and Louisiana; the Western States, the rest of the country.

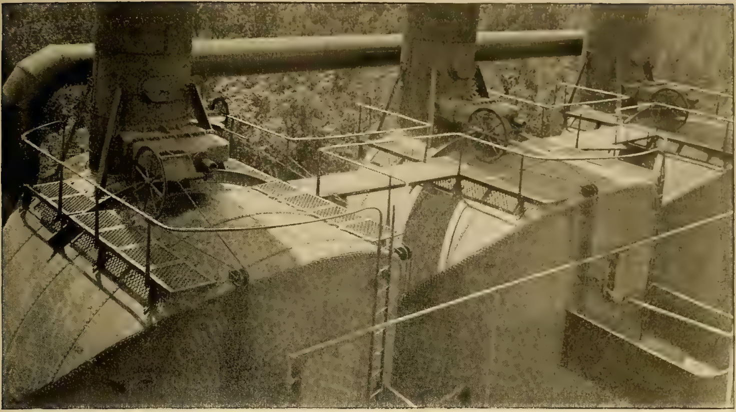
The following figures indicate that while the population of New England increased practically 500,000 souls in each decade, the amount of pig-iron produced has varied but slightly, and that this section made one ton of pig-iron for every 118 inhabitants in 1860, and one ton for each 156 of its population in 1890.

The Middle States, with a population of 7,500,000 in 1860, produced over 700,000 tons of pig-iron or one ton for every eleven inhabitants, and in the next ten years the population had increased to nearly 9,000,000, while the production of pig-iron exceeded 1,000,000 tons, so that one ton of pig-iron was produced for every seven and two-thirds inhabitants. A further increase in population in 1880 to over 10,500,000 and a pig-iron output of over 2,000,000 tons, made the production of pig-iron one ton for every five inhabitants. In 1890, a still further augmented population to nearly 13,000,000, and a production of 4,650,000 tons of pig-iron was equivalent to one ton to every two and three-quarters inhabitants.



SOME HOT BLAST STOVES.

A marked increase is shown in the Southern States which, with a population of 10,000,000 in 1860, produced about 100,000 tons of pig-iron, or one ton for every ninety-nine inhabitants; but an increase in the population to 10,850,000 in 1870, was met by an augmented production of pig-iron nearly one and two-thirds times what it was



AT THE TOP OF A SET OF HOT BLAST STOVES.

ten years before, and one ton was produced for every sixty-six inhabitants; in 1880, the Southern States had a population of nearly 14,000,000, and nearly double the production of pig-iron of 1870, so that one ton of pig-iron was made for every forty-five inhabitants; in 1890, with a population of nearly 16,250,000 and a pig-iron production of over 1,500,000 tons, the Southern States produced one ton of pig-iron for every ten and one-quarter inhabitants.

In the Western States the increase of population has been more rapid, and although the development of the pig-iron industry has been greater in amount than in the Southern States, it did not show the same relation per capita. In 1860 the population of the Western States was 10,750,000 inhabitants, and the production over 150,000 tons of pig-iron; that is, one ton was produced for every seventy inhabitants; whereas, in 1870, the population was over 15,250,000 and the production nearly 500,000 tons of pig-iron, or one ton for every thirty-two and three-quarters inhabitants. In 1880, the 21,500,000 inhabitants and nearly 900,000 tons of pig-iron, made the proportion one ton to every twenty-four inhabitants in the Western States, and in 1890, the population was 28,800,000 inhabitants and the production over 2,250,000, or one ton to every twelve and two-thirds inhabitants.

The divisions of the country as given above, do not properly represent the groupings of the American blast furnaces, and a comparison of the population and pig-iron output, made in conformity with existing commercial relations, would considerably alter the per capita output in certain sections. However, in the absence of any other generally accepted subdivision of the country, no effort will be made to follow the discussion in detail as to specific localities.

If the United States has in the last thirty years increased its relative production of one ton of pig-iron for every thirty-two inhabitants, to one ton of pig-iron to every seven and one-third inhabitants; and if the Middle States have similarly advanced from one ton to every eleven inhabitants to one ton for every two and three-quarter inhabitants, what has been, and what is, the position of Pennsylvania? Its population of less than 3,000,000 inhabitants in 1860 has increased to 5,250,000 in 1890, while its pig-iron product of but 580,000 in 1860 was augmented to nearly 4,250,000 in 1890. In 1860, Pennsylvania produced one ton of pig-iron for every five inhabitants; in 1870, it made one ton of pig-iron to every three and three-quarters inhabitants; in 1880, one ton was made for every two and one-half inhabitants, and in 1890 one ton for every one and one-quarter inhabitants.

The position of Pennsylvania is more marked when we remember that, according to Mr. James M. Swank, in Iron in All Ages, no iron was made in the State prior to 1692, and that was of such small extent that the exact location of the enterprise is not known. As a practical producer of iron, Pennsylvania's history does not commence until 1716, sixty-six years after the establishment of the industry in Massachusetts.* It would also be well to note in this connection that until 1859 no pig-iron was made in Pittsburgh, and yet in thirty-three years, the magnificent industry in Allegheny county has developed, until in 1892 a total of 1,775,257 gross tons were produced.

Another instance of remarkable development is in Illinois, no iron having been manufactured there until 1839, but in 1892, 949,450 gross tons were produced from twenty furnaces located in that State.

Allegheny county, Pennsylvania, in which Pittsburgh is located, and Cook county, Illinois, in which Chicago and Joliet are located, are the two greatest producing centres, when compared with the areas covered, that we have in the United States from which reports are published. Their aggregate output was nearly 30 per cent. of the total for 1892.

The Birmingham district of Alabama also represents very rapid development and produces a large amount of pig-iron in a limited territory, but as the official statistics are not reported separately from those of the State of Alabama, no absolute statement is offered.

A review of the above memoranda demonstrates the following: In 1860, the production of pig-iron in Pennsylvania per capita was nearly as great as that of the Middle States in 1880, twice that of the Southern States in 1890, and two and one-half times that of the Western States in 1890. The per capita output of pig-iron in the United States is now considerably less than that of Pennsylvania thirty years ago. In three decades, the output of pig-iron per capita in Pennsylvania has quadrupled, and that of the rest of the United States, in the same time, has about kept pace with the Keystone State; although the Western States show a somewhat accelerated growth of output per inhabitant, and the Southern States a remarkable increase in this particular. The oft prophesied annihilation of the blast furnaces of Pennsylvania and their removal to other localities, seems no nearer fulfillment than it was years ago.

Taking the production of pig-iron in the United States in the future at one ton for each six inhabitants (say), 375 pounds per capita annually, the Western States must double their output of pig-iron and the Southern States increase their production seventy per cent. before they supply the requirements of their present population, if that population represents average consumers.

If Pennsylvania should not augment its annual output of pig-iron one ton in the next decade, she would still, in all probability, head the list of producers, and contribute about one-third of the supply of the nation. With a wealth of fuel, ore and flux, with excellent transportation facilities to convey fuel, distant ores to, and the product from, the furnaces, and with a strong home market, the iron masters of the Keystone State are not in need of sympathy from prophets of evil; and only as the other sections of the country exceed the national per capita production, will inroads be made on the State's natural market; unless these sections also foster a development which makes the people consumers as well as producers.

A late publication, by Mr. Edward Atkinson, The Future Situs of the Principal Iron Production of the World, from which an excerpt was given concerning the probable output of pig-iron in 1900, contains the following cautious prophecy as to "the future situs of the iron production of the world:"

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*Virginia antedates Massachusetts, but its initial iron works were destroyed by Indians.

"One may not venture yet to name the specific place or places. The survival of the fittest among the many enterprises now claiming public attention will soon determine it in the emulation between the North, the South and the West.

"Suffice it that if one should stand upon the top of the highest peak among the Great Smoky Mountains in the heart of the Southern Appalachian chain, and could bring within his vision all that would come within a radius of seventy-five to 100 miles, he might be able to establish the centre of iron and steel production which would not be very far away from what has been called the 'centre of gravity' of the population of this country.

"If he could bring within his vision the whole configuration of the area enclosed within a circle of about 150 miles in diameter, centering on the Great Smoky Mountains, he might trace the lines made by the erosion of the rivers and the gaps in the ranges on which the rails may be laid to the northwest at the southern border of Ohio, and to the southeast on the way toward the Atlantic ports of South Carolina, over which the metal produced at the possible future centre of the iron production of this country may be distributed on the easiest grades, either for domestic consumption or for the supply of foreign markets."

The region referred to is known to abound in minerals suitable for conversion into pig-iron and its stores of hidden wealth are probably much greater than is now recognized. But to agree with Mr. Atkinson, we must assume that the development of the ores of the Eastern and Middle States have reached their maximum, that the great coal areas of Pennsylvania, Ohio, Indiana and Illinois are to see comparatively little future extension in mining operations for metallurgical uses, that the wonderful supply of iron ores of Michigan, Wisconsin and Minnesota, which in 1892 amounted to over 9,000,000 gross tons, or more than half of what the entire country furnished, are to make but small advances in utilization; that the ores of southern Missouri, Arkansas and Texas, and the coals near the border of Indian Territory, if developed, are not to be assembled in quantity sufficient for a large producing industry.

In addition, we must make no allowance for the exploitation of the excellent ore deposits of Wyoming, which are distant from Chicago less than fifty per cent. farther than where the present ore supply for furnaces near that city is obtained. We must give Colorado small margin for augmenting its iron industry, and omit serious consideration of utilizing the known minerals of Utah or New Mexico; we must also leave out of our calculation the possibility of the Pacific States employing their recognized mineral resources on a liberal scale.

To accept Mr. Atkinson's situs, we must dismiss the illusion that the market is a most potent factor in the establishment of an iron industry, an *illusion* (*?*) that has caused capital to embark in iron production and manufacture at points like Chicago, where none of the raw materials are indigenous, but where they can be assembled advantageously and where unusual market facilities are offered. In short, we must assume that those most intimately associated with the pig-iron industry have given no thought to its future.

Mr. Atkinson apparently treats of the future solely in the light of the past, without making due allowance for the establishment of new industrial centres following the tide of population, or for possible and probable advances in mining, preparing and transporting fuel, ores, etc., in modifying present practice or processes, or in utilizing waste materials. The next quarter of a century may show improvements which would surprise us as much as the output of some of our mines or furnaces or the present use of compressed air, electric light and gaseous fuel would have done twenty-five years ago.

The iron industries of Pennsylvania are here to stay, the ores of New York and of the Lake Superior region will continue to be in great demand, the South and the West will add to their industries; Canada and Mexico will develop their resources, iron production and manufacture will extend beyond the Continental divide and follow the tide of population rather than congregate in a limited area of mineral development. In this, the localities indicated by Mr. Atkinson will share, and possibly share liberally, but allowing for a considerable export trade, it is probable that the future situs of iron production of the United States will be considerably removed from the point indicated and that of the world still further from the highest peak of the Great Smoky Mountains, and the details of winning materials from mother earth and converting them into iron and steel will make familiar in many localities the story "From Mine to Furnace."

COMPRESSED AIR vs. HYDRAULIC POWER TRANSMISSION.

By Professor W. C. Unwin.

CONVEYING power by compressed air has been for years, and is still, so popular a theme for discussion that recurrence to a few facts on the subject may not prove uninteresting here. They were given in connection with more detailed matter in a paper presented by the author a few years ago before the Institution of Civil Engineers of Great Britain, but since that time have lost none of their pertinence.

In examining some of the calculations on which schemes for using compressed air have been based it appeared that they were unnecessarily tentative and cumbrous. In one not unimportant respect calculations about the transmission of power by air appeared to be based on a wrong principle. By analogy with the transmission of power by water it has been tacitly assumed that the frictional work in the mains is entirely wasted work. But with air it is not so. Under practically realizable conditions the whole of the frictional work in the mains may be expended in heating and expanding the air. What the air loses in pressure it gains in volume. The fall of pressure does involve a loss in transmission, because the efficiency of the pump or of the motor is affected. But in spite of this secondary loss an advantage remains to the air, and part of the frictional work is recovered.

After many years of experience the system of hydraulic transmission has been carried to a high degrees of perfection, and the conditions of uccess are well understood. To transmit power economically and efficiently by water, a very high pressure must be adopted, with a moderate velocity in the mains. This moderate velocity in the mains is dictated not only by considerations of friction, but also, more imperatively, by the necessity of limiting the stresses due to the inertia of the incompressible mass of water in the mains when the velocity changes. The whole mass of water in the mains must change its velocity simultaneously; hence, the shocks due to sudden changes of velocity are very serious. Both the high pressure and the low velocity limit the size of mains which can be used and, therefore, the amount of power which can be transmitted.

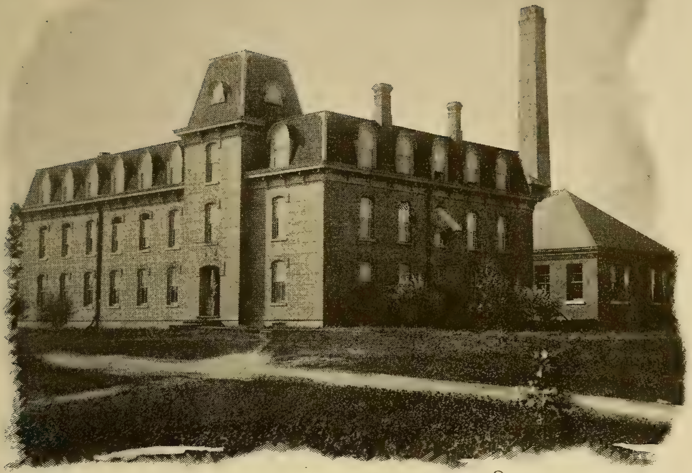
Systems for transmitting power by compressed air are not yet so completely worked out, nor are the conditions of economy and efficiency so well understood. The unavoidable heating losses in compression limit the pressures which can be used in air transmission, and it is doubtful if in any case efficiencies quite so great as those attained with water can be realized with air. Nevertheless there are cases where the moderate pressures used in air transmission are far more convenient than the high pressures required for water transmission, and there appears to be no definite limit to the size of the main which can be used, or the amount of power which can be transmitted, if necessary, by air. For three reasons the velocity of flow in the mains may be very much greater with air than with water. The friction in the mains is less with air than with water in the ratio of their densities. The frictional work is less an evil with air than with water, because part of that frictional work is recoverable. Lastly, the elasticity and small density of the air makes the danger of shocks or inertia stresses practically vanish. Water can only afford work less than the product of its pressure and volume, but air, used expansively, gives an amount of work greater than the product of its pressure and volume. Hence it turns out that with a given size of main a considerably greater amount of power can be transmitted with air of moderate pressure than with water of very great pressure.

As the air flows along the main the resistance of the surface of the main has to be overcome and the pressure falls. In correspondence with this the volume of the air and its velocity increases, and it is necessary to know the law of expansion. The work expended in friction in the pipe generates heat, and if all this heat were retained in the air then the expansion would be exactly isothermal. Thus, in a perfectly non-conducting main the temperature must remain constant, however rough the main and however great the fall of pressure due to frictional resistance. Actual mains are not non-conducting, and, no doubt, if air entered the main at a higher temperature than the surrounding soil, some heat must be lost by conduction. If, however, as has been assumed, the air enters the main at sixty degrees, which may be taken to be practically the temperature of the soil, no heat can be lost by conduction. The main is, for air at that temperature, incapable of conducting away heat, and the expansion in the main must be isothermal.

It follows from this that there is an essential difference between the transmission of power by water and the transmission by air. In the former case the frictional work in the main is wasted and lost. The heat produced in the water does in no way add to the effective work of the motor driven by the water, but with air the heat generated expands the air, and the latter does more work in the motor in consequence of its expansion. However long or rough the main, the energy of the air per pound remains constant. To the extent to which the pressure falls, the air may be less serviceable in doing work in actual motors. This, however, does not destroy the advantage of air in transmission, though it may reduce it.

INSTRUMENTAL AND COMPUTING ROOM OF THE CIVIL ENGINEERING DEPARTMENT.

A CORNER IN THE MACHINE SHOP AT THE IOWA AGRICULTURAL COLLEGE.



ENGINEERING HALL.

TECHNICAL SCHOOLS OF AMERICA.—III.

THE IOWA AGRICULTURAL COLLEGE.

By Professor G. W. Bissell.

TO the uninitiated the number of technical schools now in existence in various parts of the country may well be a matter of surprise, a vast amount of progress having been made in a comparatively quiet way during the past quarter century in the establishment of various institutions of learning, all of them interested more or less in the development of the mechanic arts and sciences. Particularly true is this of the inland States, in which, with the assistance of government subsidies, the founding of such schools has been a marked feature of the general industrial development of the country. Agricultural colleges such schools have in not a few instances been denominated, though they by no means confine themselves to instruction in agricultural departments, but perform excellent service in the comparatively wide field of technical training.

One of this number of institutions, the Iowa State College of Agriculture and the Mechanic Arts, commonly called the Iowa Agricultural College, was established under the land grant act, and formally opened on March 17, 1869.

The college is located near Ames, in Story County, on the main line of the Chicago and Northwestern railway, at the junction with it of its north and south branches, of which the latter has its terminus in Des Moines, thirty-seven miles distant. The campus, two miles from Ames, is beautifully situated on high rolling ground, and its natural advantages have been greatly enhanced by the skill and taste of the first president of the college, who laid out the drives and set the trees which to-day make the place the delight of all beholders.

The department of mechanical engineering has been recognized from the first, and its growth, though slow, has been steady, and its prosperity is now beyond dispute. The headquarters of the department are in Engineering Hall, of which the basement and first and second floors are given up to its use. The third floor is occupied by the department of civil engineering. The basement is used as a foundry, and is provided with benches, floor space, tools and flasks for ten students, and a small brass furnace and core oven. Iron castings are not made here for the want of suitable accommodations for a cupola and its accessories. The students in foundry work obtain practice in molding, core making and casting brass and alloys. The first floor is occupied by the office of the assistant professor of mechanical engineering and the machine shops. The latter are in two rooms, having a total floor space of about 3000 square feet, one end of the larger room being screened off for a tool room.

The machine shops are equipped with a twenty-four by twenty-four-inch planer, a milling machine, a universal grinding machine, a shaper, two drill presses, two emery grinders, a polishing wheel, a cutting-off machine, six engine lathes of capacities from ten to twenty inches swing and three to eight feet between centres, and three speed and drilling lathes, together with the usual assortment of small tools in the tool room, and a set of pipe cutting and threading tools for pipe up to four inches in diameter. In the machine shop is located a fan-blower for the blacksmith shop, which is temporarily provided for in a shed outside the building. The equipment of the blacksmith shop consists of eight Buffalo forges, anvils, tongs, fullers, swages, etc. Forging and welding of iron and

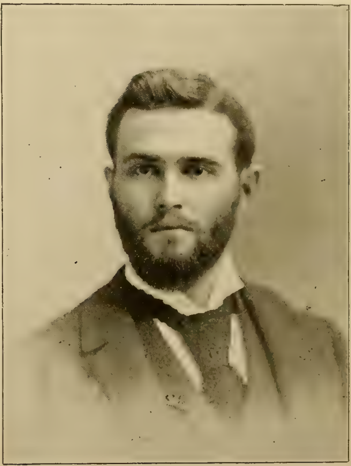
THE ENGINEERING BUILDINGS.

GEO. W. BISSELL, PROFESSOR OF MECHANICAL ENGINEERING.

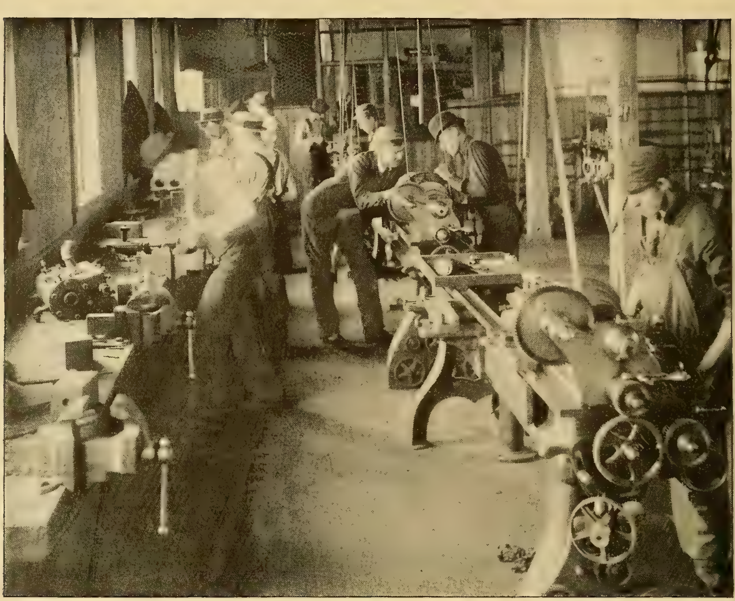
steel and the tempering of small tools are set forth here.

The second floor of the building is occupied by the office of the Professor of Mechanical Engineering, the library, a recitation room, and a large drawing room. The recitation room will seat thirty students, and the drawing room has tables for fifty, two hundred drawing boards and a considerable number of drawings, photographs and blue-prints complete the equipment of the drawing room. Both recitation and drawing rooms have ample blackboard space, which forms a valuable adjunct to the facilities for instruction. The library, in addition to reference books, contains models and the more valuable instruments of the mechanical laboratory. Besides the above room in Engineering Hall the department of mechanical engineering occupies the power house and the carpenter shop. The latter is a two-story frame building. The first story contains a universal buzz-saw, a mortising machine, planer, sticker, jig-saw and grindstone, while the second story is fitted up with ten turning lathes of various sizes, benches for twenty students, and complete sets of small tools for twelve students, together with a number of special tools. A second room on this floor serves as a tool and stock room. The work of the students in this building consists of carpentry, turning and pattern work.

The power house, which was but recently completed, contains a fifty horse-power Babcock & Wilcox boiler and a twenty-five horse-power Harris-Corliss engine. Power is carried to the machine and carpenter shops by belting and shafting. The size of this building is such that it also accommodates the mechanical laboratory of the department. The equipment of the latter, in addition to the engine and boiler just mentioned, consists of a Wheeler condenser, a two-inch Worthington water meter, a Holly duplex pump, injectors, weir and weighing tanks, a Crosby steam gauge tester, fan blowers for experimental work, a 50,000-pounds Olsen testing machine, gas analysis apparatus, two Thompson and two Crosby indicators, and one Richards indicator, dynamometers, a Brony brake, platform scales and some



W. H. MEEKER, ASS'T PROFESSOR OF MECHANICAL ENGINEERING.



ANOTHER VIEW OF THE MACHINE SHOP.

other apparatus essential and accessory to experimental engineering. The system of instruction in the shops is a combination of the exercise and the "job-work" methods, the former being abandoned as the student becomes proficient, if he also shows the possession of a sufficient amount of gumption for the latter. The drawing room work begins with freehand and object drawing and perspective, and is followed successively by machine sketching, mechanical and kinematic drawing and designing. The latter division occupies the last year and a half of the course.

Experimental work begins in the middle of the junior year and extends to the end of the course. The instruction in this subject is thorough, its scope being indicated by the following list of experiments: Tensile, transverse and compression tests of materials, properties of lubricants, measurements of power by absorption and transmission dynamometers, steam gauge and indicator spring calibration, cement testing, flue gas analysis, indicator practice, variation of engine speed, fan blower tests, calorimetry, including barrel, throttling and separating calorimeters, weir and water meter calibration, efficiency test of steam engine, boiler, injector and steam heating, electric lighting and pumping plants, and Hirn's analysis of the steam engine.

The department of electrical engineering is, at present, in charge of the department of physics, and the course of study is, for the first two years, identical with that of the mechanical engineering. Special attention is given in the last two years to theoretical work in electricity in general, and to practical work in electrical measurements. The equipment of the department of physics is available for instructive purposes, and in the power house of the department of mechanical engineering are one six-arc light dynamo, one thirty-five-light sixteen candle-power incandescent dynamo, one "pony" Westinghouse alternator and one two-horse-power motor. The Edison electric light plant of the college is available for tests.

The civil engineering department occupies the third story of engineering hall. Its rooms include a class room, seating sixty students, a draughting room with accommodations for fifty, an instrument and designing room, and the office of the department. Its equipment includes several engineers' transits and levels, and a comprehensive collection of other engineering instruments. It also has a good collection of blueprints of standard engineering designs and models of structural shapes. An illustration of the cement testing apparatus in the engineering laboratory accompanies this article. The course of study is arranged to give the student a thorough training in mathematics and the sciences as related to the work of the engineer to enable him to become skilled in technical drawing and in the use of engineering instruments, and to teach him the principles of engineering practice in designing, surveying, railroad construction and other branches.

Particular attention is given to field practice, the location of the college and the fact that the terms are so arranged that very little of the winter months is included in the college year giving special advantages for such work. Drawing, railroad construction, bridge designing, and the other subjects in the list of professional studies are taught by the usual methods.

A. MARSTON. PROFESSOR OF CIVIL ENGINEERING.

W. S. FRANKLIN, PROFESSOR OF PHYSICS AND ELECTRICAL ENGINEERING.

The writer occupies the chair of mechanical engineering, and is ably assisted by Mr. W. H. Meeker, who graduated from Sibley College, Cornell University, in 1891. A. Marston, the professor of civil engineering, is also a graduate of Cornell University, where he held one of the university scholarships. Before his appointment to the chair of civil engineering at Ames he had held the positions of resident engineer on the Indiana and Lake Michigan Railway in 1889, and of transitman, resident engineer and chief of the locating party on the Missouri Pacific Railway from 1889 to 1892. While on the latter road he had charge from 1890 to 1892 of the construction of the steel bridge over the Ouachita river near Columbia, La.

W. S. Franklin, professor of physics,

and now in charge of the department of electrical engineering, was graduated from the University of Kansas in 1887, and for the three years following was assistant professor of physics there. He received the M.S. degree from the same institution in 1888. In 1890 and 1891 he spent a year as a student in Berlin, and was afterward the holder of a Morgan Fellowship at Harvard, which he resigned in February, 1892, to accept the position he now holds at Ames.

A department of mining engineering was recently established and put under the charge of Gen. J. R. Lincoln, who is also professor of military tactics at the college.

ROPE-POWER TRANSMISSION.

By James M. Dodge, M. Am. Soc. M. E.

TRANSMISSION of power by ropes is comparatively a development of recent times. Although ropes were used in isolated cases for power purposes many years ago, it may be said, so far as the United States are concerned, that the last ten years have seen the adoption of rope-power transmission become more general and the system take a recognized place in the field of mechanical engineering. Some reference to the subject, therefore, as presented by the author to the Franklin Institute in a lecture some months ago, may prove interesting at the present time.

There are two general systems in vogue, which may be designated as the English and the American. The former employs one or more single ropes, whereas the latter uses one continuous rope and employs a tension carriage operating on one of the turns of the rope to ensure a uniform amount of work being performed by each wrap around the wheels.

Wheels or sheaves used in connection with the rope for the purpose of transmitting power are made with V-shaped grooves in the rims, the most commonly accepted angle being forty-five degrees. These grooves are made sufficiently deep to prevent the rope bottoming, or resting upon the bottom of the groove, the object of this being to increase the resistance to slipping and enable a moderate weight on the tension carriage to give sufficient driving force.

Sheaves used in conjunction with manilla rope are made in two ways, the older method being to cast the sheaves with sufficient width of face for the number of grooves desired and to roughly core the grooves, so as to lessen the amount of iron to be removed by the turning tool in finishing them. It is necessary to cast the wheels sufficiently heavy to resist the pressure of the turning tool, in order to have the finished wheels as round as possible. It is almost impossible, however, to avoid a small amount of spring between the arms, so that upon careful measurement the wheel is found to be polygonal. This is notably the case when the cut is heavy, it being necessary, in order to obtain a good result, to take a roughing cut, which releases the skin tension of the casting and permits it to take a modified shape, due to the internal strains ever present in cast-iron wheels designed to have the outer surface removed from them by turning. Then a second cut is taken, and finally a finishing cut is made with a tool ground to the exact shape of one of the finished grooves, this last cut, which is made more to true up the inequalities of the previous work, removing but very little metal. In the foundry work connected with the manufacture of these wheels, it is seldom that a wheel having two or more grooves in it is so perfect that, upon turning, imperfections are not discovered. These, of course, if too numerous, render the condemnation of the casting necessary. If, however, the sand holes, or blow holes, in the turned surface of the sheave are not too large, they are filled with babbitt metal, and the sheaves are put in use. The amount of metal turned from castings for rope sheaves is astonishingly large; for instance, in the case of a five-groove sheave of forty-eight inches diameter, for one and one-eighth inch rope, the rough weight before turning was 698 pounds, and after finishing the weight was 567 pounds, showing that 131 pounds had been turned off the original casting. This proportion would, of course, vary somewhat, dependent upon the care taken in the foundry, but at the same time it is always greater than would be supposed.

The second and newer method of manufacturing sheaves is that practiced by the "link belt" companies and differs from the already described method in two very important features. In the first place, the sheaves are not turned after being cast, great care being taken in the proportioning of the hubs, arms and rims, so that the castings can be made of extreme lightness, but being devoid of internal strain are very strong. The grooves are cast on green sand cores, a three-part flask being used. By this we mean that the flask has a cope and a drag, as is common in all foundry work, but between them is placed what is known as the "third part" or "cheek piece," which holds the sand destined to form the grooves in the finished wheel. It has been found in practice that it is possible to cast sheaves in this manner that are fully as accurate as turned ones, and with an average saving in weight of 17.2 per cent. This saving in weight, of course, effects a corresponding economy in the power required to operate a rope drive furnished with them.

The second radical difference between the "link belt" sheaves and the solid turned sheaves is, that the manufacture of multiple-groove sheaves, or those having more than one groove, is effected by bolting together what are known as arm sections (which are really complete sheaves of one groove) and rim sections (which are simply grooved rims cast without arms or hubs). This plan makes it possible to vary the weight and strength of multiple groove sheaves by using a greater or less number of arm sections, dependent upon the size of the rope to be used and the varying conditions of their employment. After the sheaves are "built up," as it is termed, they are bored out, and to show the trifling difference in weight between the rough and finished sheaves, I would state that a forty-eight inch five-groove sheave for one and one-eighth inch rope weighs in the rough 433 pounds, and when finished 423 pounds, or 144 pounds less than the finished solid-turned sheave referred to previously.

So great is the care taken in the casting of "built-up" sheaves, that the only finishing required in the grooves is that of smoothing the casting by holding a block of emery in the groove while revolving at a speed of about 120 revolutions per minute, the finishing of each groove in this way not occupying more than three or four minutes.

An incidental advantage of the multiple-groove "built-up" sheave is, that after a rope drive is erected and the necessity arises for the transmission of more power than that for which it was originally designed, additional ring sections may be added to the sheaves, and by splicing in an additional piece of rope the desired increased transmitting capacity may be secured.

It is obvious that in the use of a single rope making a number of wraps around two wheels it is essential that the diameters of the grooves at the pitch line, which is the arc of contact of the ropes, must be uniform in all the grooves in any one sheave; otherwise there would be a tendency on the part of some of the wraps of the rope to travel faster than the others, which tendency must be counteracted by the slipping of the rope in some of the grooves—this, of course, resulting in a loss of power and also in the rapid wear of the rope. So important is this feature that great care has to be taken in splicing the rope, so that the diameter at the splice will be no larger than in the body of the rope. An increased diameter at the splice would, of course, make the splice travel around a larger circle on the sheave by its not being able to take as low a position in the V-shaped grooves.

It is impossible to splice a rope without impairing its strength at the splice, provided its diameter is not increased. What is ordinarily known as the short splice or the long splice, as used by sailors, will not answer at all. It is essential that a splice (for instance, in a rope one inch in diameter) should be from ten feet to twelve feet long, and made with great care, so that after the splice is complete the tension to which the rope is subjected is evenly divided among the strands of the rope.

Durability of manilla rope transmissions is dependent upon various conditions, the most important one, probably, being the quality of the rope. In order to make good rope it is necessary that the fibres employed in its manufacture should be long and of nearly uniform size. The fact that the fibres of manilla have a rough interior and are of great strength in proportion to their weight is an important factor in the strength of the rope when subjected to a tensile strain, but at the same time this very roughness becomes an element of destruction when the ropes are passing around sheaves which cause the fibres to slide upon each other, so that the internal wear of the rope becomes a most serious agent in destroying it. A worn-out rope untwisted so as to expose the strands will show a fine powder which has been chafed off the fibres. Of course, after this has been detached from the fibres it leaves them weaker than in their original condition. It is also noticeable that the fibres of manilla, being composed of elongated cells, are not perfectly adapted to continued bending.

In order to counteract the destructive tendencies enumerated, it is essential that the rope should be lubricated. This is accomplished in two ways, the first being by the introduction of a lubricant in the manufacture of rope, notably, as in the case of what is known as the "Stevedore," into which tallow and graphite are introduced at the time the rope is made. The effect of this is to increase the flexibility of the rope, increase its life and to render it to a degree waterproof. The second method is to coat the outside of the rope with a mixture of lampblack or graphite and grease, relying upon the working of the strands of the rope with relation to each other to work the compound through it. This latter method is practiced in Europe, and is also being made use of in this country to a considerable extent.

Some of the larger constructors of rope transmissions in England claim that manilla rope should never be used under any circumstances and that cotton is the only fibre that will give satisfactory results. I have seen samples of a rope one and three-eighth inches in diameter, which had been in constant use ten hours a day for nearly sixteen years. This was a cotton rope, known as the "Lambeth," the peculiarity of its construction being that it was primarily made of cotton, but each of the four strands of the rope was covered with a number of tightly twisted yarns, forming a protecting envelope, which prevented cutting or wearing of any of the strands proper of the rope. Of course, cotton ropes are much more expensive than manilla ones, and a rope such as the Lambeth must necessarily be the most expensive of those made of cotton.

It is unquestionably true that, in time, cotton ropes will be more extensively used in crowding out those of manilla; but it is a fact that the introduction of any radical departures in the field of mechanical engineering is only possible by offering not only a more satisfactory article than has formerly been used, but also a cheaper one. This fact has aided in the introduction of the manilla rope drive, as in many cases it is not only the best means of transmitting power, but also the cheapest. Ultimately, and as users of rope drives become more familiar with their intrinsic advantages, they will be more ready to increase the original outlay and put in the best rope that can be made.

If manilla rope transmissions are designed with good judgment, and are properly erected, there is no possible doubt of their giving satisfactory results. The prevailing notion is, however, that as rope is flexible in all directions, rope drives can be constructed in a haphazard manner, without special care being exercised in getting the sheaves in exact alignment, and considerable criticism has been engendered by lack of attention to the important details. When borne in mind that a rope used for the transmission of power runs at a speed as high as 5000 feet per minute in many cases, and as a rule the rope is run in close proximity to the ceiling, which is the hottest part of a room, it is not surprising that the rope rapidly becomes dry and correspondingly brittle; hence the importance of lubricating it in some way to counteract the drying tendency. It is not uncommon to find rope transmissions erected so that the sway of the rope will occasionally bring it in contact with a beam, which, of course, results in extremely rapid wear on the outside of the rope. The fact that conditions of this kind exist is sometimes hard to discover, as when the rope is at rest it may apparently have abundant clearance throughout the path of its travel. One case brought to my attention, in which the rope was being rapidly worn out, resulted in the discovery of the fact that in its passage through the wall of a building the rope would sway and come in contact with the edge of a corrugated iron covering of the building. On calling this condition of affairs to the attention of the parties operating the drive they seemed quite surprised that such a trifling thing as an occasional touching of the rope on the corrugated iron should in any way impair the life and usefulness of the rope.

Manilla rope is usually run under a working strain equal to three per cent. of its ultimate breaking strain and at velocities varying from 3000 to 5000 feet per minute. To determine the power which any rope will transmit at a given speed it is necessary to ascertain the nature and amount of the strains to which it is subjected while running, and then to find the exact part of the total working strain which is expended in performing useful work.

Generally speaking, ropes in the American system are subjected to three principal strains—viz.: the strain due to power transmitted, that due to centrifugal force, and that due to the tension carriage weight. Besides these three there are the minor strains, due to the weight of the rope, the internal resistance of the rope to bending, and the strains required to make the rope enter and leave the wedge-shaped grooves. With good ropes, running in well-made grooves, the minor strains do not probably absorb more than five per cent. of the working strain of the rope.

As an illustration of the method of determining the horse-power of a rope, in the American system, let us assume the case of a one-inch rope traveling at a speed of 4500 feet per minute. The breaking strain of this rope is about 9000 pounds, and according to the limitation imposed by good practice, the total working strain should not exceed three per cent. of this, or 270 pounds. Deducting five per cent. for the minor strains, we have 257 pounds, which represents the sum of the three principal forces.

In order to obtain the effective strain, or driving force, it is first necessary to find the strain due to centrifugal force. This force varies directly as the square of the speed, and may be found by multiplying the square of the speed in feet per second by the weight of one foot of rope, and dividing the product by thirty-two.

The weight of one-inch manilla rope per foot is .33 pound, and the centrifugal force, therefore, equals

$$\frac{75^2 \times \cdot 33}{32} \text{ or about 56 pounds.}$$

Subtracting this from 257 pounds, we have 201 pounds as the sum of the strain due to the power transmitted and the strain due to the tension carriage weight. A series of carefully conducted tests have established the fact that a weight of (say) fifty pounds on one end of a rope wrapped half way round a sheave having a forty-five degree V-groove, will sustain, without slippage, about three and one-half times its weight at the other end of the rope. Assuming, for the sake of safety, that this ratio is as 1 : 3, it is evident, that to sustain a strain of 201 pounds on the tight side without slippage, it is necessary to maintain a tension of one-third this amount, or sixty-seven pounds, on the slack side. The effective strain, or driving force, will, therefore, be equal to the difference of these strains, or 134 pounds, which, at 4500 feet per minute, will transmit

$$\frac{4500 \times 134}{33{,}000} \text{ or 18.4 horse-power.}$$

In the same manner we find, that at a speed of 1800 feet per minute, the centrifugal force is only nine pounds, and the effective strain is 166 pounds, transmitting nine horse-power ; while at a speed of 6600 feet per minute, the centrifugal force is 125 pounds and the driving force only eighty-eight pounds, transmitting 17.6 horse-power.

On reflection it is evident, that as the speeds are increased the centrifugal force increases, and the effective tension must be reduced to avoid overstraining the ropes. At a speed of about 4800 feet per minute the ropes attain their greatest efficiency, *i. e.*, they will transmit more power with the assumed working strain than at any other speed, either higher or lower, although there is but little variation in the power transmitted at that speed and the power transmitted at either 4200 feet per minute or 5400 feet per minute, thus giving a wide range from which to choose. It is well to bear in mind, however, that the higher the speed, the greater the wear of the rope, and that for this reason the slower speed is the more economical. All things considered, speeds of from 3600 to 4200 feet per minute are the best.

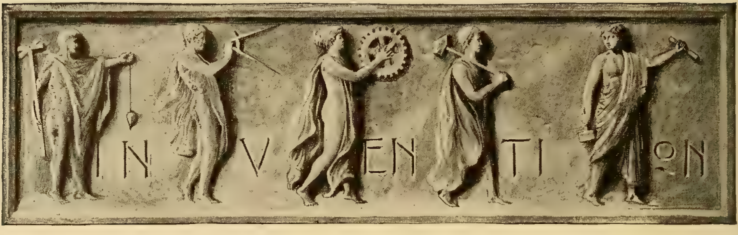
It may be well to note, that for the working strain assumed—viz., three per cent. of the ultimate breaking strain—forty diameters should be regarded as the minimum size of sheaves to be used. If it is necessary to use sheaves of smaller diameter, the working strain should be proportionately reduced ; thus in the case previously considered, an inch rope at a speed of 4500 feet per minute transmitted 18.4 horse-power ; now if it is desired to use a thirty-inch wheel as a driver, it is advisable to reduce the power transmitted to three-quarters of 18.4, or 13.8 horse-power. This rule does not only apply to the driving and driven wheels, but also to any intermediate idlers around which the rope may be called upon to bend.

The idlers of rope transmissions have usually been made with semi-circular grooves, permitting the ropes to rest upon the bottoms of them. It has been found better, however, in practice to use the V-shaped groove for all purposes, as it insures a revolution of the idlers at the same speed at which the rope is traveling, and thus prevents the wear due to the slipping of the rope in the grooves of the wheel. It has been shown, that idlers having semi-circular grooves in them become highly polished, while those having V-shaped grooves do not. Thus the demonstration that the ropes slip to a certain extent in passing over idlers with the semi-circular grooves, is complete.

The use of the tension carriage in the "American" system of rope transmissions is twofold. In the first place where a continuous rope is used passing over the grooves of two sheaves, it is obvious that the rope must be wound spirally around the two wheels, and that unless the rope in passing off the last groove of one of the wheels is not conducted back again to the first groove of the wheel, the drive would become inoperative, from the fact that all the wraps of the rope would soon run off and leave the wheels without connection between them. In order to make this return, the wheel of the tension carriage is set at an angle, so as to enable it to make the proper return of the rope. Secondly, the tension carriage is weighted, so as to give the proper tension to the rope and serve as a corrective agent to the trifling inequalities that may exist in the sheaves or in the rope. It is by the weighting of the tension carriage that we are enabled to tell the exact amount of strain to which we are subjecting a rope. I might add that, the tension carriage being mounted on guides, it is capable of maintaining the proper tension of the rope even if the latter becomes considerably elongated by the strain put upon it, or is variable in its length due to atmospheric changes. This latter is especially noticeable in rope transmissions which are used wholly or in part out of doors, they being subjected to the action of rainy and dry weather.

The use of wire rope for the transmission of power I will only briefly touch upon by stating that the economic use of it seems to be confined to transmissions of great length. The sheaves employed have to be of very large diameter, otherwise the rope becomes short-lived.

With reference to raw hide, I might say that its cost has prevented its general adoption, as it is cheaper to use an increased number of strands of manilla rope to accomplish the desired result ; though it has one marked advantage, inasmuch as it is possible to use it on sheaves of smaller relative diameter than in cases where manilla rope is employed. If possible, in running the rope, care should be taken to have the bends all in one direction, as a rope bent in opposite directions will wear with much greater rapidity.



NOTES ON NEW AND PATENTED INVENTIONS.—VIII.

By John Richards, M. E.

AMONG the many new patents relating to pumping machinery, that of Mr. M. W. Hall, No. 482,944, granted September 20, 1892, is of especial interest.

Mr. Hall, the inventor of the pump described in the above patent, has already contributed some valuable features in such apparatus. His duplex pumps, which received the honor of an award of the Scott medal by the Franklin Institute of Philadelphia, are among the unique, as well as valuable improvements in the intricate art of "moving fluids," as Mr. Hawksley of London calls it.

These pumps are very well known as almost the only duplex type with steam-moved valves, and operating by a peculiar motion of the pistons that permits the valves to close easily at each end of each stroke. This was a successful attempt to improve the action of pumps, but not to alter the methods or principle, to so call it, on which reciprocating pumps act.

Since the introduction of the Hall duplex pumps there has been a good deal learned respecting internal forces set up in pumps with intermittent flow. The diagrams of Professor Riedler, recently mentioned in these articles, disclosed operating conditions, even of high-class pumps, that were a revelation. He pressed reform as far as one man usually does in such cases, but it is evident to most persons that much remains behind. He increased the speed of pump pistons from 100 feet to 300 feet a minute, and closing valves without noise or jar, but he "closed" them, consequently only improved the old methods, adding "positively moved" valves, improved water ducts, higher efficiency and doubled the duty.

Now there is dimly seen a possibility of the valves of such pumps not closing at all, and of a continuous flow. We can also see approaching some recognition of the fact that crank motion is not adapted to pumping at all, that is to economical and still pumping, and that the water following the ordinates of a crank curve is a most unnatural kind of operation.

This we know is a revolutionary proposition, considering how great a share of our water pumps are operated by cranks, but if one will stop to consider a body of water fifty to 100 feet long, weighing 62.5 pounds to a cubic foot, following the variable movement produced by a crank, it will seem absurd. Suppose, for example, hoisting machinery for goods or passengers was operated on such a method, and that the load was picked up by half strokes of a crank and so propelled? While no one would think of such a thing, this is the common method of raising and forcing water from the intake to the air vessel.

These remarks bring us to Mr. Hall's present patent. It contains a large number of drawings and diagrams, only a small portion of which are reproduced here, but sufficient to illustrate the main features of the invention.

In the drawing below, which is a side view of one of the pumps, *A A* represents two pump barrels arranged in the U form, and equivalent to one straight barrel with the two bucket-pistons moving in opposite directions. It is equivalent to "bending the barrel around," so to speak, so the two pistons, instead of moving oppositely, can move together. It is not a common arrangement, one adopted at first, so far as we know, by Swiss makers, and called valveless pumps, because no valves are employed except those in the pistons. *C* is the inlet, and *D* the discharge way.

In the present case, however, the pistons do not move together, but with a rapid inward and slow outward or working stroke, controlled by the driving cranks *B* and *a a*, with links and levers, as shown, producing an uniform working movement, as indicated in the diagram, Fig. 2, which is thus referred to in the specification :

"Fig. 2 is a chart showing graphically the relative movements of the pistons, the vertical lines being spaced apart to represent equal intervals of time—namely, thirty-sixths of a revolution, or ten degrees—while the curved lines indicate the positions of the respective pistons at the successive intervals of time."

In another part of the same specification there are the following words relating to continuous flow :

"Pumps as ordinarily constructed impart an intermittent movement to the column of water, the column being first lifted by the thrust of the piston, and coming to rest and remaining seated against the check-valve during the return stroke of the piston, so that upon the beginning of the next stroke the column has to be again started against the resistance offered by its inertia."

These double-barreled bucket pumps are by far the nearest to producing a continuous flow when operated by direct steam pressure or other means of producing an uniform rate of movement during the working stroke. This is precisely what the inventor is aiming

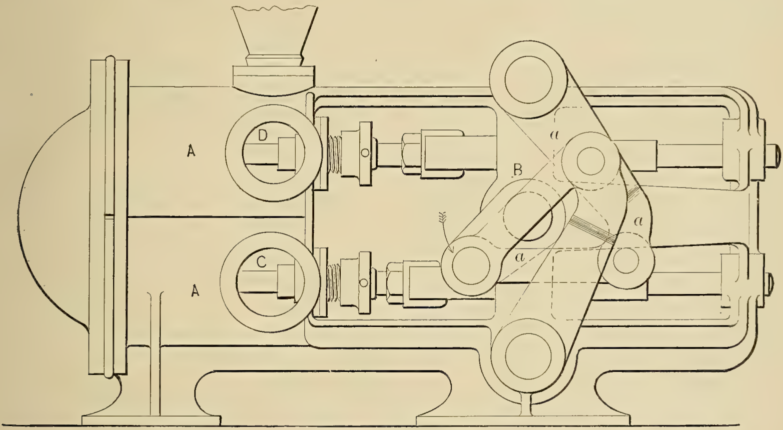


FIG. I.—HALL'S DUPLEX PUMP.

at, and has accomplished here, as is set forth in a preamble to the specification, but one cannot help wishing the crank eliminated when it involves expensive gearing subject to wear, and directed to functions which it seems should be attained without a crank at all.

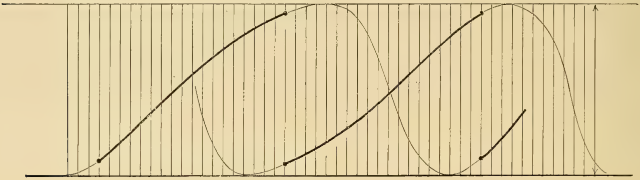


FIG. 2.

The functions and results foreshadowed in the present invention, if we mistake not, point to some entirely new modification of pumping apparatus in the near future. We have gone on for some centuries raising and forcing water by “jerks” instead of pushing it, a method that would not be thought of in connection with any other kind of mass having equal weight, or any appreciable weight for that matter. A reason for this is that in all of our conceptions of fluids their mobility is the chief characteristic, and we do not conceive of a six-inch pipe filled with water being the same in weight and much less elastic than a bar of iron two and one-quarter inches in diameter of the same length.

Just at the time of writing this there came to hand an account by Mr. Arthur Rigg, of London, of a high-speed continuous flow pump employed in a water-works near London. It is of the bucket plunger type, with tortuous passages, but capable of continuous flow to such an extent as to avoid shocks. Mr. Rigg is an engineer of good professional standing, and we mention his views as coinciding with what has been written respecting pumping by “jerks.”

U. S. Patent No. 486,318, Nov. 15, 1892.

ALBRO—WORM GEARING.

The geometry and literature of worm gearing, or tangent gearing, which is a much better name, is voluminious and complete if it were not for the idiosyncrasies of the gearing itself, and its refusal to conform to the graphic and written laws laid down for its operation. Of this, however, we will speak further on, first noticing Mr. Albro's proposition, above shown, to divide the screw into three portions, as shown at *A*, *B*, *C* in the drawing, the transverse axis of the thread or convolutions being on the lines *D*, *E*, *F*, radial from the centre of the wheel, which seems impossible unless the screw is cut by a milling tool.

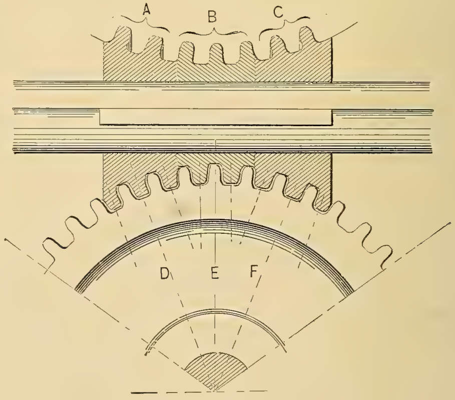


FIG. 3.

The inventor says one object of this construction is to provide for cutting the screw or worm in an ordinary lathe, in which case the axis would be parallel for each convolution on each section of the screw, but this is no matter if the pitch of the two sections *A* and *C* can be attained, or made to correspond to the angular velocity, there will be three bearing points in the gearing. This is the main object of the invention, and is certainly a feature of much value when accomplished by any means, or in any manner.

The best that can be done is a "short line" of contact, and that seems to be sufficient under reasonable strain or pressure if the conditions are correct, and this brings us back to the original remarks as to the behavior of tangent gearing. Such gearing sometimes wears out at once, irrespective apparently of strain, want of lubrication or other discoverable cause. Again it will go on for a decade without much care, attention, or even the cleaning that all sliding joints are supposed to require. It is a kind of mystery to the practical man, until by evolution or accident he hits upon the required pitch, shape of teeth, and other conditions that give longevity and comfort.

Without considering the written graphics and theory of the matter, the first problem in the workshops when such gearing is made is where shall the pitch be taken for the wheel? At the centre, base, or end of the teeth? That is, at what point on the teeth of the wheel shall the pitch be the same as that of the screw? There seems to be no determinate reason why the pitch should be taken at one place more than another. The shape of the teeth is rapidly changed as the pitch line is moved out or in, but the operating conditions seem the same, so it becomes a problem of relative strength between the teeth of the wheel and the convolutions of the screw, and it is safe to assume that no rule is applicable in all cases.

If, for example, the wheel is to be of cast-iron and the worm of steel, then the greatest strength possible should be given to the teeth, the pitch being taken near their base. Then again the shape of the thread on the screw determines the form of the teeth or the opposite, but chief of all is the main fact that, as before said, no one seems to know when such gearing is to operate without wearing out, and "disintegrate" itself by abrasion, until experiment has shown the way.

U. S. Patent No. 484,412, Oct. 18, 1892.

FOSTER DICKIE—CAR COUPLING.

Among some thousands of ways that have been invented for connecting together railway cars none seems to meet the ideal of railway people, and one feels slowly inclined to think that the plain links, hook and turnbuckle of English and Continental trains as nearly perfect as any other mode of connecting.

There is certainly something incongruous in great beetle-headed structures one sees on modern passenger coaches in this country. It is, of course, not fair to criticise without understanding all the conditions of use and abuse, but why it should require five times as much metal to connect a train in one case as in another is certainly an open query. Perhaps it is on the principle of those obscure causes that require half a ton of railway carriage to haul a passenger on smooth iron rails, and only a hundred pounds or so of land vehicle to haul the same passenger over cobblestones and all kinds of rough roads.

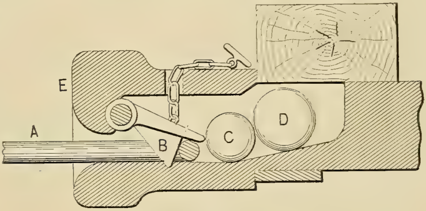


FIG. 4.

In the present coupling will be detected a novelty in the rolling detent balls, *C* and *D*. *E* is the main head, *A* the coupling link, and *B* the key latch or pawl that holds the link. When the pawl *B* is raised by the chain shown on top, and the link withdrawn, the smallest ball *C* rolls under the pawl and holds it up until a link is again inserted, pushing the balls back to the position shown in the drawing. The rear or larger ball is required because the front one rolls on a nearly level plane and requires the larger one as a driver.

Here the reader may ask what the balls are for, inasmuch as the pawl will be lifted just the same when a link is inserted, and there seems no reason for holding it up in the interval, or when not in use.

This we cannot answer and need not, because the purpose is to call attention to the peculiar functions of rolling detents of the kind in cases where such appliances are subjected to jar and concussion. The more they are shaken the more tenaciously they perform their function, and the principle is applicable in a wide range of cases where screws, split pins, springs and other contrivances cannot be relied upon.

Another example of the rolling detent is shown in Fig. *A*, a kind of clutch frequently employed on the Pacific Coast in the case of reversible winding gearing for elevators and light hoisting apparatus. *E* is the keyed on or fixed part, *D* the driven or detaining part, commonly a friction wheel embraced by a strap or clamp. When moving in the direction *B* the rolling detents *a* offer no resistance, but in the direction *C* they "jam" on the upstroke and hold tenaciously. These parts *a* are steel pins cut off a round bar, their diameter about half that of the shaft to be connected, and their length about two diameters. With fair castings no fitting is required, the whole goes together "in the rough." The method is, of course, confined to horizontal shafts.

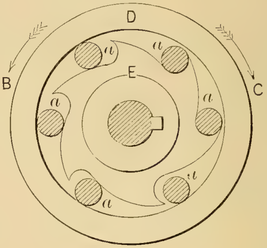


FIG. 5.

Current Topics.

THE idea of getting motive power from the ignition of gunpowder in some form of engine cylinder was proposed and practically applied as far back as the latter part of the seventeenth century. Experience with it since that time, however, does not yet seem to have sufficiently demonstrated its impracticability to some people to discourage further attempts at its developments, and for years it has periodically reappeared in some modified form. A coal dust engine, recently patented in Germany, has practically all the main features of the early gunpowder motor, and it is safe to say that it will prove equally useless. The inventor proposes to grind coal to an impalpable powder, then carry it into the cylinder of an engine by an air current, and, finally, to explode it very much after the manner of gas engine operation. We are not told, however, how the solid portion of the products of combustion are to be got rid of, nor to what extent the advantages supposed to grow out of this direct utilization of the coal are to make up for the expense of grinding it. The unavoidable residue from combustion which would accumulate in the cylinder would, in itself, be a serious obstacle to overcome, while the pulverizing is not by any means a cheap operation. Those who have proposed and tried any of the several schemes of burning dust coal under boilers know this to their sorrow.

THERE is an endless variety of uses to which nickel-in-the-slot machines will successfully lend themselves, and it is scarcely surprising, therefore, that their number is growing apace. Probably one of the latest applications of the principle governing their operation is found in the hot water fountains which have been brought out in France and which would seem to be eminently well adapted to supply one of the wants of principally the poorer classes of a city's population. These fountains are put up in the public streets and afford the convenience of supplying at any hour of the day or night a certain quantity of hot water in return for a coin of certain value, which is dropped into a slot in the now so familiar way. The dropping of the coin automatically governs the flow of water from the street mains through a small boiler, heated by a series of gas jets, and similarly regulates the quantity ot gas which is admitted and which is lighted by means of a small, constantly-maintained igniting jet. A number of these machines have been placed at different points in the streets of Paris and apparently have proved to be profitable investments, being well patronized. For each coin inserted, something like eight liters of water, at a temperature of about 130 degrees Fahrenheit, are delivered. A penny-in-the-slot gas meter is another novelty of somewhat similar character, recently introduced by one of the English gas companies. By putting a penny in the slot a customer gets twenty-two and a half feet of gas. The company sets up the machine and furnishes the necessary fixtures and a griller free of charge. If desired, pennies may be put continuously into the slot, until the index pointer registers 450 feet of gas. In this way customers, it is stated, pay about eighty cents a thousand feet for their gas, or ten cents a thousand more than the regular price, the extra charge being for the use of the fixtures and the griller.

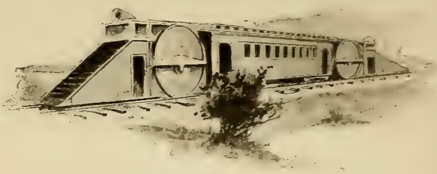
A PARISIAN HOT WATER FOUNTAIN.

THE French hot-water machine brings back to mind very strikingly the apparatus, designed more than 2000 years ago by Hero, of Alexandria, which has already been mentioned in these pages and which furnishes one of many similar illustrations of the extent to which the ancients made use of what are often supposed to be entirely modern ideas. Curiously enough, Hero's machine, it may be here repeated, was operated not by the conventional nickel, or five-cent piece, but by a coin representing five drachmas. The coin, in falling, struck a lever, opened a valve, and let out a small quantity of holy water. When the coin fell off the lever the valve was closed. Hero went still further, however, by inventing an automatic bartender on the coin-in-the-slot principle. This was a vase containing three kinds of liquor, in different compartments, with a faucet arranged so as to be opened part of the way by one coin, still further yet by a larger or heavier coin, and then still further by a still larger or heavier coin. The extent to which the faucet was opened determined which chamber should communicate with it, and hence which of the three liquors should be allowed to escape. This machine, apparently, has not yet been reinvented and might be suggestive to this latter-day generation.

IN one of the papers by Mr. John Birkinbine, entitled "From Mine to Furnace," the last of which appears in this issue, an illustration is given showing how culm is conveyed back into a coal mine for refilling the excavations from which coal has been taken. The object of doing this, as may be imagined, is, to begin with, to prevent the caving in of the earth above, and the consequent loss of property which has been experienced in the past in not a few mining towns of the anthracite regions. Besides this, however, the method of culm filling permits the removal of the valuable pillars of coal which, for many years, it was customary to leave in the mines to prevent the falling-in of the roofs, and finally, it affords, in a measure, a solution of the problem of how to dispose of the unsightly heaps of coal dust and slate which are such conspicuous land-marks in the coal mining districts. In view of the general interest attached to these mine-refilling operations, it may not be amiss to refer more particularly to the manner in which they are conducted at one of the prominent Pennsylvania collieries. A coal-dirt conveyer, consisting of a series of semi-circular shutes, similar to those used in discharging coal from carts into cellars, commonly used in large cities, and an endless chain with scrapers attached automatically convey the fine refuse from the coal breakers to an elevation, whence it is discharged into a second shute. As the coal dirt falls on this second shute, water pumped from the interior of the mines mixes with it and carries the fine coal dirt, in a semi-liquid state, back through a jig or puddling hole into the bowels of the earth, from which the coal has been removed. The coal dirt settles to the bottom of the breasts and packs closely, and the water seeks an outlet below, to be again pumped out to repeat its duty. The cost of thus puddling the refuse matter back into the mines is comparatively very small compared with the value of the pillars of marketable coal of which the mines may be safely "robbed," and the security obtained for dwellings and railroad property on the surface above the mines. Already extensive subterranean spaces from which coal had been mined in various parts of the country have been solidly refilled with coal dirt in this or in an essentially similar way, and the method promises to grow in application.

Transportation methods, old and new, some that have stood the test of years, and others again that have yet had little to commend them to attention but novelty and daring enterprise, form not the least interesting features of the great exposition at Chicago. From the primitive ox-cart up to the latest development of nineteenth century ingenuity, the various methods of getting about are strikingly portrayed in Transportation Hall, and the interested spectator is furnished with overwhelming demonstration of the vastness of the progress that has been achieved in this line by human intellect. Among the several exhibits of proposed methods of transportation is an operating model of an electric car, chiefly remarkable because of the high speed which it is expected to attain with it, a rate of from 100 to 150 miles an hour being spoken of. At each end of the car there is a wedge-shaped electric motor attachment, resting between wheels ten feet in diameter, the wedge form evidently having been decided upon as a means of diminishing the resistance of the air to be encountered at the contemplated high speed. What may be practically accomplished with the design remains yet to be seen.

AN ANCIENT IDEA OF RAPID TRANSIT.



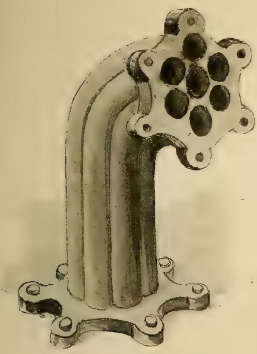
ONE HUNDRED AND FIFTY MILES AN HOUR.

Looking at the double-pointed car brought to mind the story of the rather interesting solution, worked out by some inventive genius several years ago, of the problem of how to enable two railroad trains to pass each other on the same track without collision. The frequent attempts of trains to thus pass each other have been attended so uniformly with disastrous consequences that the feat has become pretty generally recognized as an impossible one, and most engineers have concluded to desist from further efforts to accomplish it. The plan of the genius in question, however, was after all, very simple, as most really great plans and ideas are. He proposed to place on the front of every locomotive going in one direction a long inclined plane, not unlike the one shown above, and on this were to be two rails. These were to come close to the regular track at the forward and lower end of the plane, and at the upper end were to be connected with other rails running along the tops of the cars and down to the main track again on another inclined plane at the rear end of the train. It was explained that when the train provided with this attachment would meet another train on the same track, the latter would simply go over the former, its weight making the connection of the front of the inclined plane and the rails of the main track perfect, and acting, at the same time, as a brake on the speed of the train underneath. It is, of course, perfectly evident that if this invention had been properly appreciated and generally adopted, the number of double-track roads the world over would not now be half as great as it is. A single track, with occasional switches for heavy freight trains, would have answered all purposes, and the cost of building railroads would have been decreased by an important percentage. The inventor, of course, fondly hoped to see the system adopted immediately on all single track roads, so that, in a few years, the sensation of riding over or under another moving train would have been so common as to pass almost unnoticed.

FIRE room practice aboard ocean steamships, with special reference to the almost insufferably high temperatures to which both boiler and engine room occupants seem to be needlessly exposed, has been a theme of considerable discussion. Almost every one with an engineering turn of mind who has crossed the Atlantic in one of the fast modern steamers, and who has had opportunity to investigate a little on his own account, has some story to tell of the excessively hot regions in the depths of these floating palaces, and of the correspondingly trying conditions under which the men must work, upon whom so much of the vessels' efficiency depends. A good deal of printers' ink also has been used up in trying to impress shipowners with the fact that fairly comfortable boiler and engine rooms are not impossible things to attain, and that they would yield even profitable returns by helping, in no small measure, to increase the working capacity of the crews. Very little, however, has been done in actually improving matters, and, with a few exceptions, atmospheric conditions in boiler and engine rooms aboard large steamships are now about as bad as they can possibly be.

THERE are two ways in which a fair degree of comfort may be secured in such vessels. One of them consists in providing ample facilities for the escape of hot air, and correspondingly easy means of ingress for cool air. It will not suffice, however, to simply open skylights over engine and boiler rooms. Hot air can get out only if cool air can get in to take its place, and if dependence be put simply on open skylight areas, there will be a constant struggle between different volumes of air at different temperatures to change places. Wind sail ventilators, if carried clear down to the bottoms of the spaces to be cooled, would effectively produce a constant rush of air up through the skylights, and would thus serve an excellent purpose. It seems hardly necessary to add that the entering air should be divided up into streams in different directions, securing, as much as possible, uniformity of distribution. Another means of reducing temperature consists in carefully clothing steam pipes, engine cylinders, up-takes, in fact, all heat radiating surfaces, with some kind of non-conducting covering. In this way alone a very appreciable improvement could be brought about. Ventilation, however, must be looked to as the most promising remedy. Blower outfits have been installed in a number of ships with very gratifying results, the cool air in these being discharged exactly where wanted and in volumes under easy control, and the results of experience with them have demonstrated quite conclusively that the existence of highly overheated quarters in most vessels can be best explained by the niggardly, or, at best, the too economical policy of the owners.

Ever since the occurrence, a few years ago, of several disastrous explosions of large copper steam pipes on board of some British steamships the question of how to prevent or, at least, to minimize the risk of such mishaps has received considerable attention. The evidence given at the time at the inquiries into the causes of these explosions and the experiments which were made in the course of the investigations demonstrated very clearly that an element of no little danger exists in the current practice of brazing large, heavy, copper pipes intended to carry the high steam pressure which are now so common. It always has been generally admitted that welds or brazed joints in any kind of material are of uncertain character, but in the case of copper, worked over a fire, this uncertainty, as tests have shown, is very much increased. With the almost absolute necessity of using copper pipes in many situations, therefore, the problem of how to give them greater resisting power became an important one. One solution of this problem has been offered in the shape of what is known as the Ferranti steam pipe, which is built up, so to speak, of several pipes of small diameter having a combined area equal to the area of the single large pipe which they are designed to supplant. The fact that each of the small pipes is naturally stronger than a large pipe, and that the small pipes, moreover, may be of solid drawn copper, while large copper pipes must be brazed, sufficiently explains the merit of the invention. However, although brought out two or three years ago, we do not remember its coming into any extensive use.

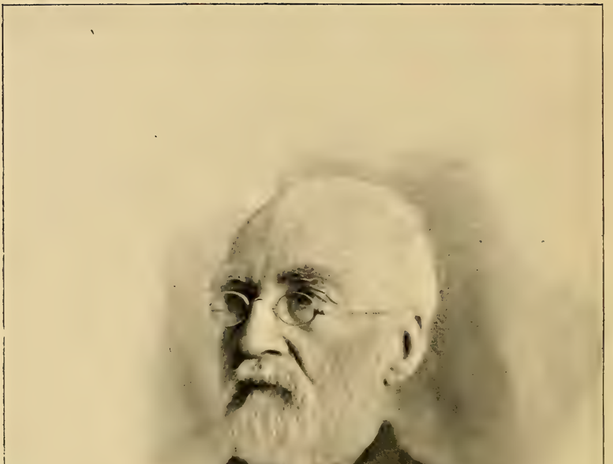


THE FERRANTI STEAM PIPE.

It has also been repeatedly proposed to reinforce copper pipes by shrinking steel rings around them, but it seems to have been shown quite conclusively by experiment that unless these rings are very closely spaced the pipes have practically no greater resisting power than plain ones. The latest plan of strengthening copper pipes is to serve them over with one or more layers of closely laid wire, wound on under tension, and is said to have been definitely adopted in the Italian navy. Up to about eight inches in diameter drawn tubes are used without reinforcement. Above this diameter, however, the tubes are made out of copper sheets by brazing in the usual way, and are then wrapped round with a close spiral of copper or delta metal wire. This method of reinforcement is considered applicable only to straight tubes, and accordingly, these only are used, gun-metal castings being adopted at the bends. The wire is said to be of sufficient section to carry the full steam pressure independently of the strength of the tube, but the latter is made strong enough to stand the usual hydraulic test before the wire is put on. The reinforcement is made up with two or three independent spirals, so that if one wire breaks the tube is still held up to its work by the others. The tension under which the wire is wound on is stated to be about one and one-half tons per square inch.

Water jet propulsion for ships seems to have a peculiar fascination for a great many inventors. Year after year its supposed merits have been dinned into the ears of people likely to interest themselves in it financially, and in a number of cases actual trials have been made with a view of practically demonstrating that the advantages claimed for it really exist. None of these experiments have ever given the slightest encouragement to the scheme ; still, like Banquo's ghost, it will not down and, at present, it is again being vigorously advertised. Its promises, of course, are of an alluring kind. In place of complicated engines to drive screw propellers or paddle wheels, we have simply, so the promoters tell us, to provide a few pumps, a boiler, or perhaps several boilers, to supply the steam necessary to work them, and a nozzle in the stern of the vessel. The pumps will take in water through orifices in the bow or at the sides of the ship, drive it out at high pressure through the nozzle at the stern, and reaction will do the rest, propelling the boat forward at variously stated speeds. The cost of the whole outfit, it is argued, will be comparatively low, the space occupied also will be small, and the expense of maintenance of the machinery will be materially reduced as compared with that of the currently used installations aboard ship. The drawback to the whole thing, however, is that the system will not work, or rather that it will not work in a commercially satisfactory way.

It is not necessary to go into anything like a detailed mathematical presentation of the subject here in order to show how utterly futile all attempts must be that aim at the useful, practical application of such water jet methods of propulsion. A few figures will be amply sufficient. Let us take, for example, the case of one of several of the boats which were tried a few years ago. As described at the time, the nozzle at the stern of this boat was intended to discharge a stream of water about one and one-fourth inches in diameter at a pressure of something like 10,000 pounds per square inch, and the speed to be developed was placed at thirty miles an hour with an estimated horsepower of 1500. The boat itself measured about 110 feet over all, had a beam of twenty-three feet, and a draught of water of about four feet. Theoretically, the velocity of the issuing jet should equal the speed of the boat, which in this case would be, approximately, forty-four feet per second. A simple calculation then shows that, in order to accomplish what was claimed, about seventeen tons of water per second, or a little over 61,000 tons per hour, would have to be discharged through the nozzle at the stern, a performance which, of course, is preposterous. A scarcely less formidable quantity would have to be handled at lower speeds so that even at a quite modest estimate of the possibilities of the scheme, no thought of its feasibility can be reasonably entertained. It seems almost needless to say, in the face of this, that the boat did not revolutionize things in the way of ship propulsion and that the project was abandoned. Somewhat similar methods, in which jets of steam instead of water were to be used, have also been brought forward at different times. With these, as may be inferred, there was to be even greater simplicity of working outfit than in the case of the hydraulic jets, the boilers which furnished the steam being all there was in the way of machinery. Toy boats, a few inches long, propelled after this method, are common enough, but for actual service in any but such boats, the steam jet system has probably nothing to commend it over the other. For the same results there would have to be as much steam discharged in the one case as there would be water in the other, and the quantity of coal which would have to be burned under the boilers to generate this steam for even a short time only, would be interesting to contemplate. How to find room for it on board of any vessel on which it was to be used, and how to pay for it without entailing hopeless bankruptcy of the users has never been explained by the advocates of the system.



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CASSIER'S MAGAZINE.

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FAST OCEAN STEAMSHIPS.

By Dr. Francis Elgar.

THE subject of fast ocean steamships, with special reference to vessels of the latest type, such as the new Cunard steamers Campania and Lucania, was suggested to the author some time previous to the past summer meeting of the British Institution of Naval Architects as a desirable one for discussion before that body, and he was requested by the secretary to read a paper concerning it. In response to that invitation he prepared substantially the following, in which that remarkable example of marine architecture, the Great Eastern, very appropriately received prominent attention.

It may be remarked, at the outset, that our present knowledge and experience of many of the conditions that limit or influence speed at sea, and of their separate or combined effects, are by no means exact or exhaustive. In considering the general question of the proportions, power and detailed arrangements requisite for a ship in order to absolutely ensure that the highest possible average speed shall be obtained, and kept up over an indefinite number of long ocean voyages, under the restrictions imposed by the existing conditions of ship, engine and boiler construction, harbor and dock accommodation, etc.,—a question which would be a mere matter of calculation, if all the circumstances affecting it were fully and accurately known—we find that the answer depends ultimately, to a great extent, upon personal judgment, and is open to be materially affected by hopefulness or imagination. It would be unprofitable to attempt to enter upon such a speculation here, and I resist the temptation to do so. It might perhaps be more useful and appropriate to call attention to a few of the principal points that affect speed at sea, and some of the directions in which theory and experience show the way to continued improvement.

The Great Eastern is the most wonderful instance the world has seen of attempts to obtain high speed over long distances at sea. She was designed forty years ago, and her name is probably associated in the minds of most people only with errors and disaster. It is universally known that she was remarkable for her enormous size; but it is often forgotten that there was anything else about her worthy of notice or admiration. Every new ship that is built of greater dimensions than her predecessors is naturally compared in

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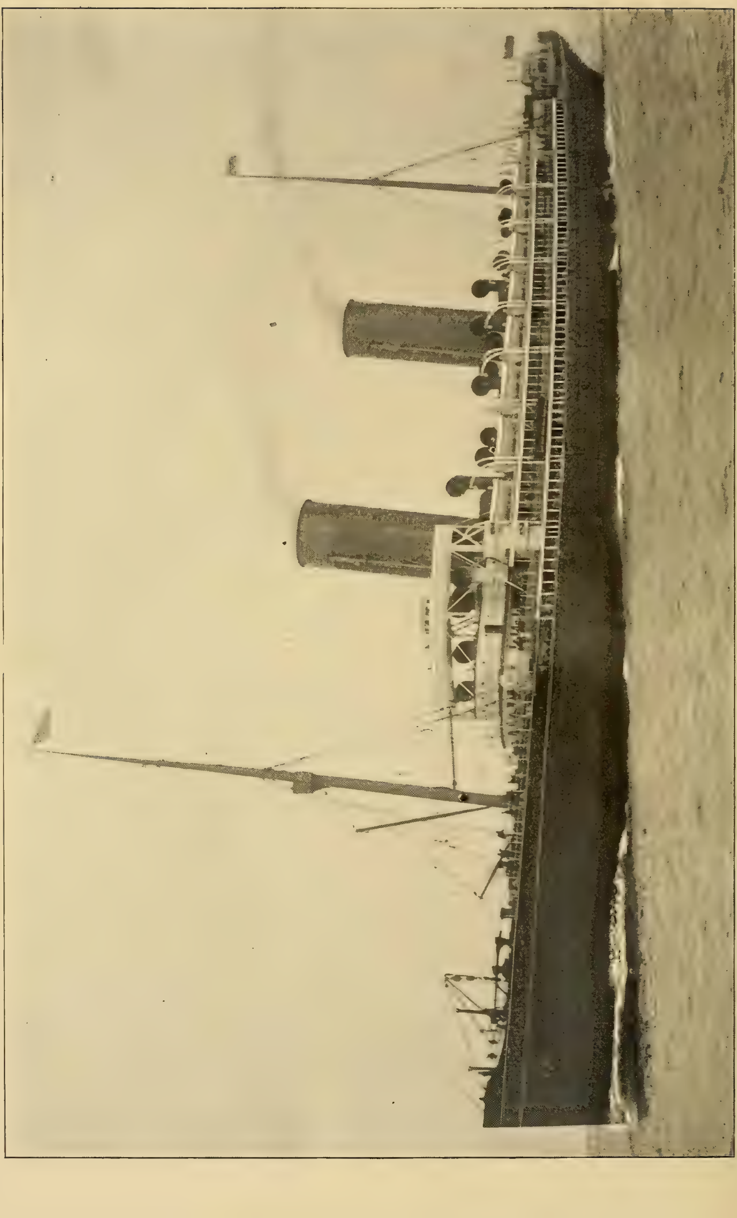


THE TWIN SCREW STEAMSHIP CAMPANIA OF THE CUNARD LINE, 1893. LENGTH, 622 FEET; 30,000 HORSE-POWER; 12,950 TONS. MADE THE FASTEST OCEAN TRIP ON RECORD, IN 5 DAYS, 12 HOURS, AND 7 MINUTES.

size with the Great Eastern. The Great Eastern was remarkable, however, not only for the vastness of her proportions, but also for the thought, care and skill employed in her design and construction, and for the extent to which problems relating to high speed upon the longest ocean voyages, some of which are at times thought to be peculiarly modern, were understood and worked out by her designer.

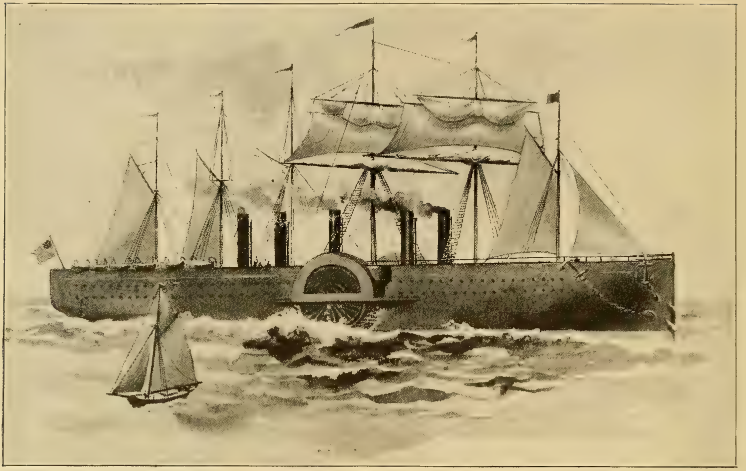
In the latter part of 1851, Mr. Brunel began to work out his idea of a great ship for the Indian and Australian trade. He spent two years in inquiries, investigations and calculations relating to the numerous problems—many of them quite novel then, though more familiar now—that were raised by such a tremendous stride in advance of all former experience and ideas. The magnitude of the stride was as great as would now be involved by the construction of a ship 1200 feet long and of thirty to thirty-five knots speed.

The following is a comparative statement of particulars of the Great Eastern and Campania :

Particulars.		Great Eastern.	Campania.
		Ft. In.	Ft. In.
Length over all		692 0	622 0
Length between perpendiculars		680 0	600 0
Breadth molded		82 2	65 0
Depth molded to upper deck		58 0	41 6
		Tons.	Tons.
Register tonnage	Gross	18,915	12,950
	Under deck	18,837	10,267
		Ft. In.	Ft. In.
Load draught		30 0	27 0
Passenger accommodation	1st class	800	600
	2d "	2,000	300
	3d "	1,200	700
Indicated horse-power of engines		about 8,000	about 30,000
Speed at sea in knots at full power		14 to 14½	22 to 23

The Great Eastern had two separate sets of propelling machinery, one driving a screw propeller, and the other a pair of paddle wheels. The screw engines were the most powerful, and could indicate up to 4500 horse-power at sea. The paddle engines indicated 3500 ; so that the maximum I.H.P. was about 8000. This power gave a speed of fourteen to fourteen and one-half knots at sea, with a coal consumption of about 400 tons per day. There were four cylinders to each set of engines, those of the screw engines being seven feet in diameter, with a stroke of four feet, and those of the paddle engines six feet two inches in diameter, with a stroke of fourteen feet. The screw was four-bladed, and had a diameter of twenty-four feet, with forty-four feet pitch. The paddle wheels were fifty-six feet in diameter. The working steam pressure appears to have been about twenty pounds, and steam was cut off in the cylinders at one-third of the stroke. The boilers were tubular, and of the square box type, and they were double ended. There were ten boilers in all, eighteen feet long, seventeen feet six inches wide, and fourteen feet high, with 112 furnaces.

The Campania has also two separate sets of propelling machinery, but in her case they drive twin screws. The propelling power is fully three and a half times that of the Great Eastern, and the speed more than fifty per cent. greater. This increase in power and speed is obtained with a daily coal consumption that is but little in excess of the Great Eastern's. There are five cylinders to each set of the Campania's engines, and they work three cranks. There are two high-pressure and two low-pressure cylinders, and the high-pressure cylinders are placed upon the low-pressure. The cylinders are thirty-seven inches, seventy-nine inches, and ninety-eight inches in diameter respectively, with sixty-nine-inch stroke. The screw propellers are smaller than that of the Great Eastern. The boilers are



THE GREAT EASTERN, 1859.—LENGTH 680 FEET; 24,000 TONS.

thirteen in number, twelve being double-ended, and one single-ended, with 100 furnaces, or twelve furnaces less than in the Great Eastern.

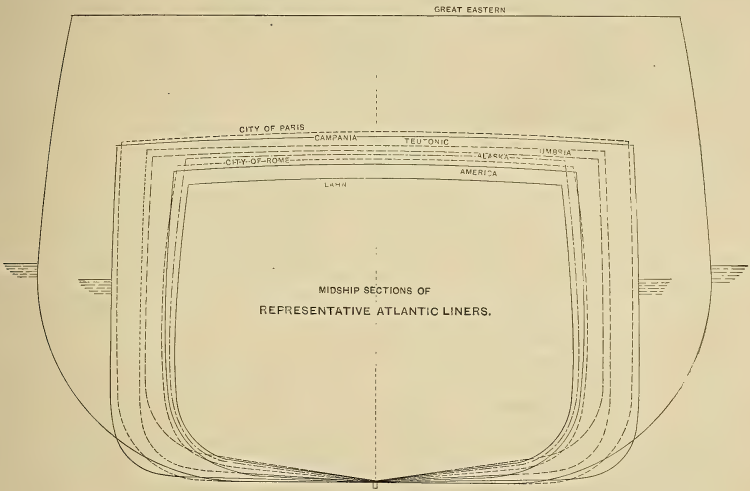
In comparing the main structural features of the Great Eastern and the Campania, one of the chief differences is that the main structure of the hull is much deeper in the former vessel than in the latter. The Great Eastern was a flush-decked ship, with no erections on deck, except a few small houses at the middle line, and the molded depth from this deck was fifty-eight feet, making the vessel 11.7 depths in length. The Campania carries upon her upper deck—in conformity with the type of vessels that has been developed for the accommodation of the largest number of passengers—two tiers of decks. The first, or promenade deck, consists of forecastle, poop and midship deck for passengers, nearly 400 feet long. This deck is practically continuous, the midship part being separated from the forecastle and poop only by a small break at each end. Upon the promenade deck a large amount of first-class passenger accommodation is provided, which includes library, drawing and music rooms, smoking room, twenty state rooms, etc. The second, or shade deck, is carried right across the promenade deck as a shelter to the passengers, and it extends fore and aft over the whole length of that deck. Upon it are carried the boats, cabin accommodation for the captain and officers, chart room, wheelhouse, etc.

The molded depth from the upper deck of the Campania is forty-one feet six inches, making her fourteen and one-half depths in length. The molded depth from the shade deck is fifty-nine and one-half feet, which is only one and one-half feet more than the molded depth of the Great Eastern from the upper deck.

Apart from this difference in molded depth, the main features of the structural design of the hull are very similar in the two cases. There are several complete iron or steel decks, the upper one being of great extra strength ; a bottom made very strong by means of inner bottom plating and longitudinals, and a very similar amount and arrangement of internal subdivision of the hull by water-tight bulkheads.

Mr. Brunel communicated his views

respecting a great steamer for the Indian trade to the directors of the Eastern Steam Navigation Company, after discussing them with Mr. Scott Russell and others. This company was formed in 1851 to convey mails, passengers, etc., by the Overland route between England and India and China, with a branch to Australia. The Government, however, gave the contract for the whole service to the Peninsular and Oriental Company in March, 1852, and the Eastern Steam Navigation Company found itself in the position of being unable to carry out the objects for which it had been incorporated.



They then turned their attention to the main oversea route followed by British commerce round the Cape toward India, China and Australia, which was nearly the same as far as Ceylon. "On the fact of this great pathway of commerce they grounded, and not without plausible reasons, their scheme for the profitable employment of various vessels of gigantic size between England and Ceylon, from which place smaller vessels were to diverge to the other parts of India, as well as to China, Japan and Australia, the intention, however, being to despatch their first great vessel, when ready, direct to Calcutta, Sydney and Melbourne."*

Mr. Brunel reported as follows in March, 1853, to a committee appointed by the directors to confer with him upon the design of the great ship: "The dimensions arrived at by calculation for this ship would be, in round numbers, 670 feet long, eighty feet beam. This sized vessel would combine most of the advantages which we seek to obtain. It would carry coal to Diamond Harbor (in the Hooghly) and back to Trincomalee; it would afford room for about 800 separate cabins, larger than those now fitted up in packet ships, with large saloons capable of accommodating 1000 or 1500 first and second-class passengers, and would carry 3000 tons weight of cargo, without making any allowance for that increase of speed proportionate to the mere increase of size, of which we see every day fresh proof; the average speed of the ship, with the proposed power of engine and calculated consumption of coal, would be fourteen knots at the average, making the passage out in

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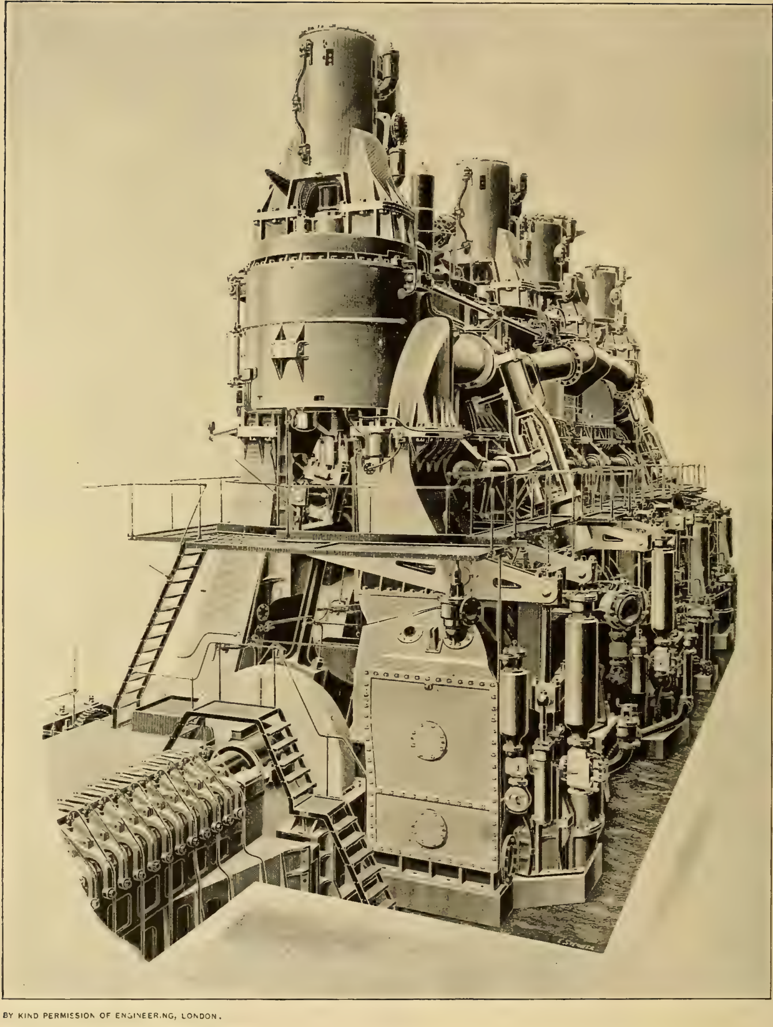
* "History of Merchant Shipping and Ancient Commerce," vol. iv., page 488 (W. S. Lindsay).



BY KIND PERMISSION OF ENGINEERING, LONDON.

TWIN FIVE-CYLINDER, TRIPLE EXPANSION ENGINES OF THE STEAMER CAMPANIA.

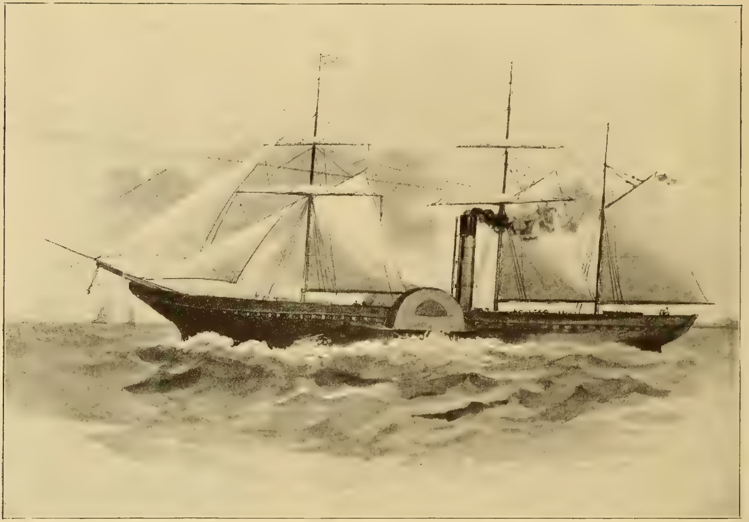
thirty-four and one-half days, say thirty-six; but with that increased speed which has been shown to take place with increased dimensions, we may speculate upon the voyage being performed in thirty days.

"This same vessel, fitted up for the Australian voyage, and loaded deeper, would carry coals to Australia and back; would take out 3000 passengers easily and a small amount of cargo only, but could bring back any amount that could be conveniently collected; or if provision were made for taking in 3000 or 4000 tons of coal in Australia, that additional amount of cargo might be taken on the passage out. The passage out to Port Philip should be made easily in thirty-six days and home by Cape Horn in the same time."

Mr. Brunel was authorized to continue his communications with shipbuilders and engineers and to invite tenders. The contract for building the vessel, as slightly enlarged to 680 feet by eighty-two feet, was signed at the end of 1853. The hull and paddle engines were given to Messrs. Scott Russell & Co. of London, and the screw engines to Messrs. James Watt & Co., Soho Works, near Birmingham. Mr. Scott Russell wrote as follows to The Times on April 20, 1857: "My share of the merit and responsibility is that of builder of the ship for the Eastern Steam Navigation Company. I designed her lines and constructed the iron hull of the ship, and am responsible for her merits or defects as a piece of naval architecture. I am equally responsible for the paddle-wheel engines. . . . . It is to the company's engineer, Mr. I. K. Brunel, that the original conception is due of building a steamship large enough to carry coals sufficient for full steaming on the longest voyage. He at the outset, and long before it had assumed a mercantile form, communicated his views to me, and I have participated in the contrivance of the best means to carry them into practical effect."

Sufficient capital was raised to build the ship, which the directors stated could be completed in eighteen months and "which would undoubtedly, according to all existing experience, pass through the water at a velocity of fifteen knots an hour, with a smaller power in proportion to tonnage than ordinary vessels now require to make ten knots." The first plates of the flat portion of the bottom were laid on May 1, 1854; but it was not until November 3, 1857, that she was ready for launching. The launching operation was, as is well known, a disastrous failure, and the vessel was not got into the water till January 31, 1858. The cost of the launch is said to have amounted to about $600,000, and the company's funds became exhausted. The vessel lay in the Thames for more than a year with all work stopped upon her, when she passed into the hands of a new company called the "Great Ship Company." She made her first steam trial in September, 1859, and as the trade for which she was originally intended could only be worked, if at all, by a number of such ships making voyages at regular and not too long intervals, with smaller vessels in the Indian ocean to distribute the freight and passengers among the Eastern ports, this idea had to be given up. She was accordingly put into the Atlantic trade, and made nine transatlantic voyages between 1860 and 1863. Upon the fourth voyage, with 400 passengers on board, the rudder head was twisted off and the paddle-wheels damaged in a heavy gale, and the vessel was obliged to put back to Queenstown. On another voyage outward to New York she passed over a reef of rocks off Long Island Sound, which tore the bottom plating open in ten places, and made one hole eighty feet long and ten feet wide. Her very complete subdivision protected her against anything more than local damage, and most of the passengers landed in ignorance of an accident which would probably have proved fatal to any other existing vessel.

The Great Eastern's speed upon the Atlantic sometimes reached fourteen and one-half to fifteen knots average during one day, with a draught of water on leaving port of about twenty-eight



THE FIRST CUNARD LINE STEAMER, THE BRITANNIA, 1840. LENGTH, 207 FEET; 403 HORSE-POWER; 1139 TONS. TIME OF FIRST TRIP FROM LIVERPOOL TO BOSTON, 14 DAYS AND 8 HOURS.

feet. Upon one voyage her speed averaged thirteen and three-quarter knots outward and fourteen knots homeward. The highest average speeds upon the Atlantic in 1852, when the Great Eastern was designed, were about ten knots. It will thus be seen that the anticipations with regard to her speed were not without justification.

Owing to the impossibility of working upon the Atlantic at a profit the ship passed into other hands, and was afterward occupied chiefly in cable laying. After the demand for her employment in this work fell off, she lay many years uncared for in Milford Haven and was at last sold and broken up.

The Great Eastern was a failure commercially; but from a mechanical point of view she was in all her main features successful to a degree that was marvelous when compared with the standard of the time. Mr. Brunel did not know the "law of comparison," taught us by the late Mr. Froude, which shows how the power required to drive a ton of displacement at a given speed in a small ship becomes reduced as the dimensions are increased in similar ships; but he well knew the fact that the proportion of power to the displacement becomes less as a ship is increased in size for the same speed. He acted upon this principle in 1836 in the design of the famous Atlantic steamer Great Western, and carried it to an extreme length in the design of the Great Eastern.

Mr. Brunel said: "I never embarked in any one thing to which I have so entirely devoted myself, and to which I have devoted so much time, thought and labor, and on the success of which I have staked so much reputation." This will be understood when the responsibilities of the designer of such a vast and novel work are considered. Almost everything had to be thought out and arranged for, with but very little help from existing ideas and experience. Mr. Brunel said in one of his memoranda: "Every part has to be considered and designed as if an iron ship had never before been built; indeed, I believe we should get on much quicker if we had no previous habits and prejudices on the subject."

The lines were designed by Mr. Scott Russell upon his wave-line principle. The cellular construction of the hull and the inner bottom, with the very complete internal subdivision into water-tight compartments, an arrangement that would fulfill the most modern and stringent requirements, were due to Mr. Brunel. Investigations upon the rolling of ships, with special application to the design of the Great Eastern, were made for Mr. Brunel by his friend, the late Mr. William Froude. Mr. Brunel also wanted to experiment upon the relative resistances in water of clean copper and painted iron surfaces, with the view, at first, of having the outer shell of the Great Eastern of wood, sheathed with copper. He appears to have finally settled upon iron, because of the difficulty of devising any means of dealing exhaustively with the question, and because he doubted whether, with a very long surface, the smoothness would much affect the total resistance.

THE VIKING SHIP.—LENGTH, 78 FEET.

Having dealt at this length with the subject of the Great Eastern I will pass on to some of the general questions involved by the growing demand for increased speed at sea. There are already several ships that can cross the Atlantic at an average speed of over twenty knots, or twenty-three statute miles per hour. The Campania crossed from Sandy Hook to Queenstown, on her first voyage in May last, at an average of 21.3 knots, and during one day she averaged 22.3 knots. These speeds are a little over twenty-four and one-half and twenty-five and one-half statute miles per hour respectively. It is thus already possible to cross the Atlantic at as great a speed as journeys of the same length could be made on land by all but the fastest railway trains. The Canadian Pacific Railway, for instance, takes five days nineteen hours between Montreal and Vancouver, a distance of 2906 miles, giving an average speed of a little less than twenty-one miles per hour.

There are various standards by which the speeds of ships are judged. We have the trial speeds, which may be determined by a series of runs over a measured mile, or by runs over various distances in smooth water at sea; we have runs for a certain length of time in ordinary weather at sea; and, finally, we have the average speed which a ship can maintain, year after year, over the whole of her voyages in all seas and all weathers.

The last-named is the kind of speed now under consideration. Among the conditions essential to high speed, as thus defined, are: (1) Great size of ship; (2) a form suitable for driving easily at high speeds over heavy seas without shipping heavy water, or lifting the propellers sufficiently to cause racing; (3) deep draught of water; (4) steadiness in a sea way; (5) great strength of structure and of machinery; (6) a large proportion of boiler power, so as to enable a full supply of steam for the engines to be easily kept; (7) a full and well-regulated supply of air to the furnaces.

The well-known effect of size upon speed in still water, which is explained by Froude's "Law of Comparison," is not the only one that gives great size of ship an advantage at sea. There is an additional advantage at sea in a large ship, due to the waves being smaller in proportion to the dimensions of the ship, and to the pitching motion being less in a heavy sea as a ship is increased in size. The speed of a ship at sea approximates more nearly to that obtained in still water with the same propulsive power the larger she is made. No doubt length is the principal element of size in this respect, but depth, or draught of water, is also very important. Whatever might be the speed obtained with a ship on trial in smooth water, the extent to which her average sea speed would afterward approach this would depend very greatly upon her size. A striking proof of this is seen in the increasing regularity—as distinct from increase of speed—with which steamers make their voyages as their size is increased. The variations in length of voyage from the average become less with increase of size.

The effect of size upon speed is the same in sailing ships as in steamers, and is shown by the reduction in the average times of voyages to Australian and other far-distant ports to which large sailing ships trade as size is increased. The full effect of form upon average speed at sea, over long voyages and in all weathers, cannot be measured by still-water trials. One of the chief points in connection with the form best adapted for sea speed is that it should offer resistance to pitching. The fineness of ends that would give the best results in smooth water requires to be corrected by the fullness necessary to prevent undue pitching. It is only the judgment and experience of the naval architect that can decide where the line is to be drawn between the two directions. If he err on the side of fineness, as tempted perhaps by the desire to obtain the highest possible still-water results, he will lose in speed when there is any sea; and if on the side of fullness, he will lose by excess of resistance in smooth water, and perhaps at all times. Mr. R. E. Froude has pointed out that pitching tends to increase resistance; but there is, in addition, the further consideration that it practically limits speed in a heavy sea. The engines require to be slowed as soon as a ship pitches so as to take heavy water on board, or to lift the propellers sufficiently out of the water to cause racing; and it is the ship that moves easily over the seas without requiring the engines to be slowed on account of pitching that makes the best passages in bad weather. Circumstances which thus influence and often limit speed at sea

THE SANTA MARIA, COLUMBUS' FLAG SHIP.

are not taken into account in still-water experiments, and I doubt if it would be possible to arrange to do so in a way that would be satisfactory in any experiment with models.

Deep draught of water is a most important element of speed at sea, and it is now strictly limited by the depth of water in the ports and docks used by the fast passenger steamers on both sides of the Atlantic. Twenty-seven feet is the extreme limit of depth to which a ship can load on either side. The Campania cannot load an inch deeper than the Umbria, although she is 100 feet longer. If the underwater dimensions of the Campania had been increased proportionately to those of the Umbria, her draught of water would have been thirty-two and one-half feet. This class of steamers is increasing in length and breadth, but the draught of water has to be kept the same. The result is that it is only a question of time, and not of a very long time, with our present materials of construction and type of propulsive machinery, to find an absolute limit of speed imposed by the restriction of draught of water. It is not only that the present limited draught of water will finally impose an absolute limit of speed, other conditions remaining the same; but it has already a very prejudical effect in keeping down speed at the point actually reached. If the draught were not restricted, the form of section could be improved by giving to it more rise of bilge and an easier curvature. The resistance could be reduced by giving the section such a form and proportions as would increase the draught of water. At the load draughts of present ships the indicated horse-power required for a given speed does not vary as the displacement with increase or diminution of draught of water. It often varies as about the two-thirds power of the displacement.

In some cases it mav be as low as the square root. In other words, as the displacement is increased by increase of draught, the power required to drive a ton of displacement at a given speed becomes reduced. Hence, increase of draught does not mean a proportionate increase of engine power, even when such increase is obtained merely by extra immersion, without any improvement of form, such as would otherwise be possible. The advantages of increased draught would be felt still more in a sea way than in smooth water, as the lower part of the hull would be less affected by the wave surface, and better and more constant immersion could be given to the propellers.

Steadiness is important, not only as a very desirable comfort to passengers, but also as contributing to speed. When a vessel is rolling heavily from side to side her resistance must be increased. This is shown by the fact that whereas bilge keels have an appreciable effect upon speed on a smooth-water trial, they cause no reduction in speed upon sea voyages ; at any rate, that is my own experience. The advantages of bilge keels are well known in the Royal Navy, but they are not generally understood in the mercantile marine. They are often objected to on the ground of the increased frictional resistance they offer. This increase of resistance is, however, fully compensated for at sea by the reduction of resistance due to diminished rolling.

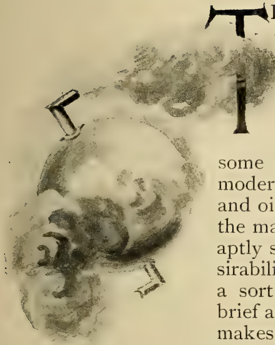
It would add greatly to the comfort of passengers if rolling could be reduced in these large steamers, and bilge keels furnish a ready and certain way of doing it, when they are properly fitted and are of appropriate size. The objection in some of the largest ships is that the docks they have to use do not admit of it. None of the fast Atlantic steamers are so fitted. Rolling chambers, containing water free to move from side to side, have been tried in some ships, but I understand they have sometimes failed in their action under the worst conditions of the heaviest rolling. The New York and Paris were fitted originally with rolling chambers, but I am not aware that they were ever used. Strength of structure and machinery is a matter of the greatest importance in all steamers that require to make quick passages in bad weather, as must be self-evident, and I need not say much upon it. A good margin of weight pays in the long run, both in hull and machinery, by reducing the amount necessary to be expended annually upon up-keep and repairs, and preventing the taking of a costly vessel off her station, and losing her earnings, occasionally for the purpose of repairs. It also contributes materially to the maintenance of a high average speed by preventing temporary breakdown or stoppage of machinery at sea. It is a question, however, whether the limit of length has not now been reached with the present structural arrangements ; and whether the promenade deck shown in the Campania should not, as a next step, be made the structural upper deck of the ship. This would be approaching more nearly to the proportions of the Great Eastern. It would necessitate some modification of the arrangements under the present promenade deck, but this is a step which now appears to be called for, and it would certainly be necessary with any further increase of length to increase the depth of the main structure of the ship in this manner. If this be not done, the vibration is likely to be excessive, especially when the revolutions of the engines approach to synchronism with the period of vibration of the hull.

Twin screws are now becoming usual in the largest class of passenger steamers. They were a necessity in the latest Atlantic liners, if only because of the necessity of keeping down the size of the machinery by dividing it into two sets. The immunity thus given against total breakdown of the propelling machinery is now appreciated, and no single screw ship is likely to be built again for the Atlantic passenger trade. The number of propellers is more likely to be increased in the future than diminished. The two engine rooms are usually divided by a middle line bulkhead, but it is necessary to have watertight doors in this bulkhead to admit of free communication between the two engine rooms. In the event of accident these doors would be closed. The objection often made to a middle line bulkhead, that water upon one side would list the ship, is met by the arrangements for admitting water ballast upon one side of the double bottom, which would counteract any such list.

In conclusion it may be again stated that the improvements that would have the greatest effect in promoting the increase of speed at sea are increase of depth of water in harbors and docks such as would admit of much greater draughts of water being obtained, and improvements in boilers by which greater steam power could be developed out of the same space and weight.

SOME OIL STEAM ENGINES.

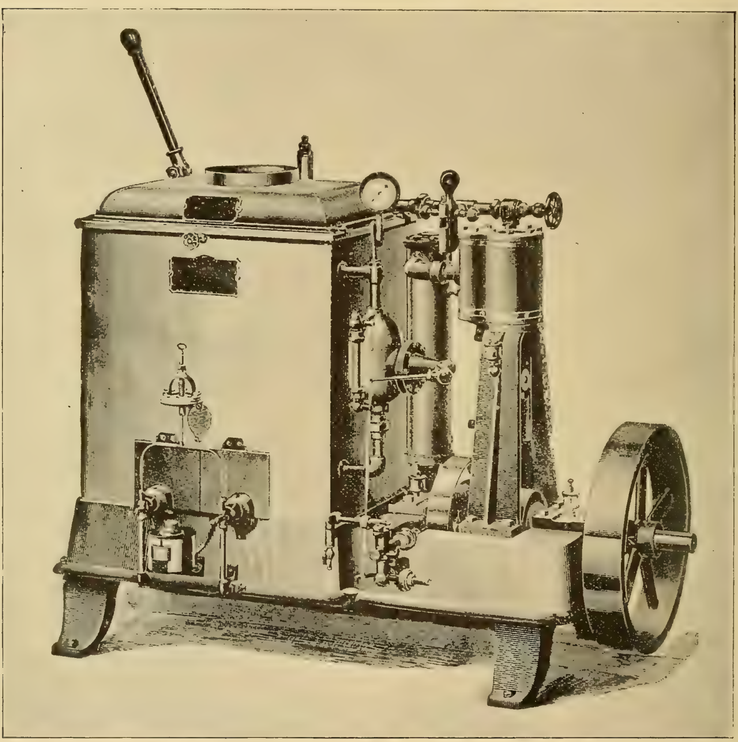
By Albert Spies, M. Am. Soc. M. E.



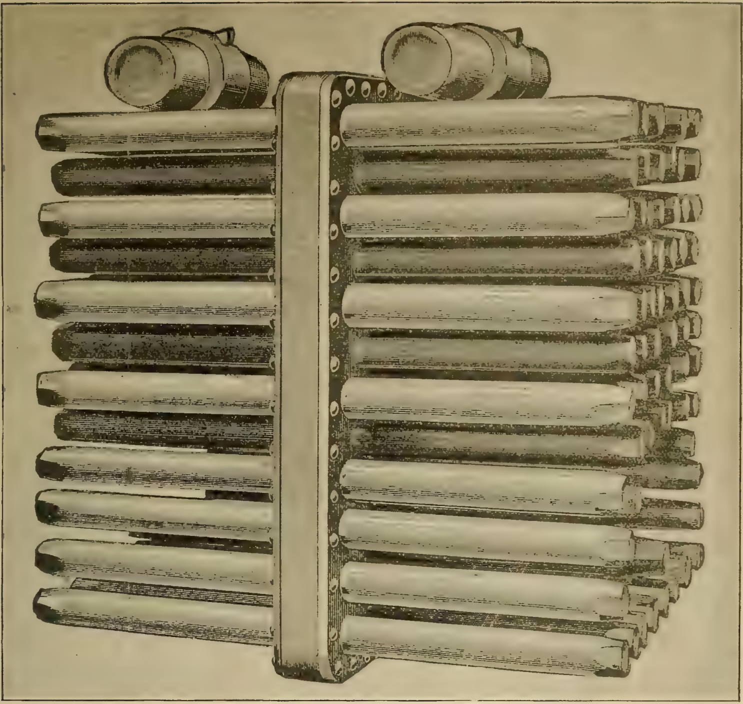
THE series of descriptive articles, given by the writer in recent numbers of this magazine, of some of the various modern types of gas and oil engines now on the market, has not inaptly suggested the desirability of adding, as a sort of appendix, a brief account of several makes of small steam engines which have come into extensive use for much the same kind of work, but which, unlike the general class of steam engines, are worked in conjunction with small, oil-fired boilers, and, hence, have here been suggestively termed oil steam engines. Like oil and gas engines, they require practically no skilled attendance, are easily manipulated, entirely automatic in operation, and might, in short, be said to take care of themselves after having once been started. The oil burnt under the boilers is introduced into the furnaces in exactly the required quantities to maintain a certain steam pressure and supply, and the pressure itself is made to exercise all the functions of a controlling attendant, reducing or cutting off the oil supply when a set limit of pressure is attained, and again turning it on when there is a fall below that limit. The oil, which, by the way, is a good quality of kerosene, gives a clean fire, without dust, ashes or smoke, and is practically free from danger. The whole outfits, in fact, admirably commend themselves, as a number of years of experience have shown, for all those purposes which call for moderate amounts of power and comparative cheapness of operation, and where simplicity and safety are important desiderata.

Many small shops, especially in out-of-the-way localities, have found these boiler and engine combinations to fill the proverbial "long-felt want," and the uses to which they have been satisfactorily applied can be better imagined than enumerated. Not content with the field for stationary outfits, however, the several builders of these engines have made successful bids for marine work, and small boats by the score have been fitted up by them with uniformly pleasing results.

Among the earliest of these engines is that known as the Shipman, familiar, no doubt, to many readers of this magazine, but of which, nevertheless, the accompanying illustrations may not prove uninteresting at this time. The engine proper is made simple or compound, as desired, and is built upon the same frame as the boiler. The valves are of the piston type. The boiler, made both single and double, dependent upon the power to be developed, is composed of tubes about eighteen inches long, screwed into a flat, oblong chamber at one end and closed at the other, and is fired externally. Two small atomizers, taking steam from the boiler, carry the oil fuel from a chamber below into the furnaces in the form of a fine spray. A couple of torches ignite this spray as it passes inward, and the flames produced by its combustion rush round and among the boiler tubes. The amount of steam and petroleum that is used by the atomizers is regulated by a diaphragm connected to a valve in the steam pipe that supplies them. This diaphragm is exposed to the steam pressure on one side, and is held down by a spring, loaded to a certain pressure, on the other, and moves upward or downward as the steam exerts more pressure than the spring, or *vice versa*. Its movement is conveyed to the regulating valve by means of a rod, thus controlling the amount of



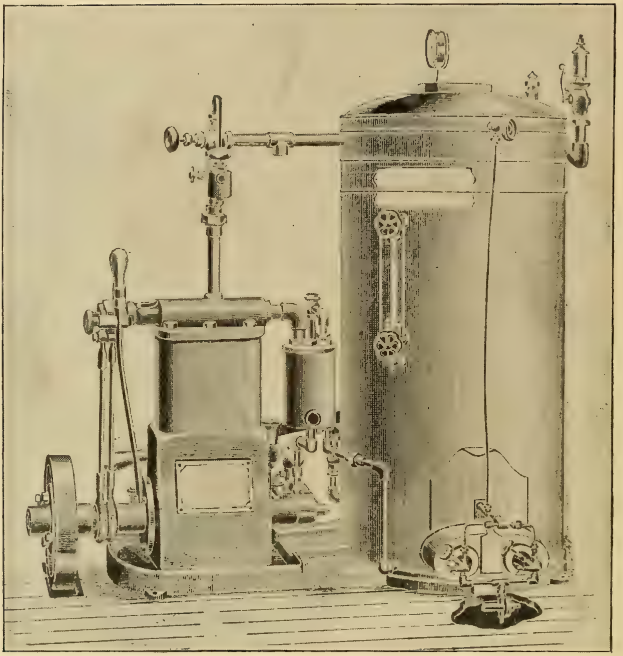
THE SHIPMAN ENGINE, BUILT BY THE SHIPMAN ENGINE CO., BOSTON MASS.



A SHIPMAN DOUBLE BOILER WITH CASING REMOVED.

steam passing at any moment to the atomizers. In this way the fire is made to vary inversely as the pressure in the boiler, and thus keeps the latter constant.

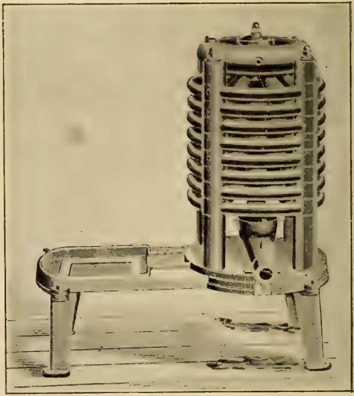
The petroleum is stored in a tank at any convenient distance from the motor, and is led to it through a pipe provided with a regulating valve. The water in the boiler is kept at a constant level by means of a float, connected to a tap in the suction-pipe of the pump. This float is placed in a chamber, which is joined to the top and bottom of the boiler, and rises and falls with the level of the water. The movement is conveyed, by means of levers, to the tap in the suction-pipe, which is opened or closed as the case may be. Before finally escaping from the engine the exhaust steam passes through a feed water heater, which, on page 96, is represented by the drum shown set on end between the engine and the boiler. Regulation of the speed of the engine is effected by a shaft governor operating directly on the eccentric. When once steam is up, the fire, the water supply and the speed of the engine require no further attention ; but when first starting, a sufficient pressure is required in the boiler to work the atomizers, and for this a hand air-pump is provided. A few strokes of this pump will suffice to start the fires, and it is only necessary to pump slowly for about five minutes to raise



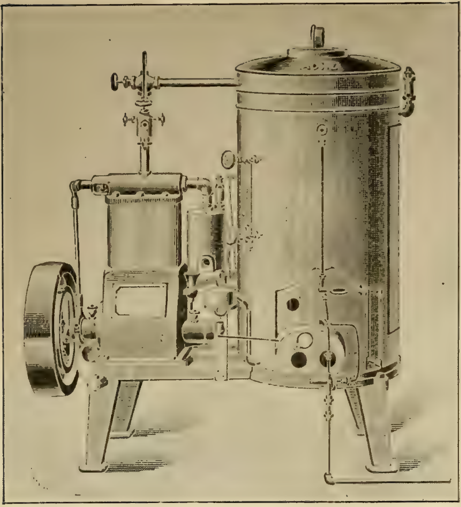
THE ACME MARINE ENGINE, BUILT BY THE ROCHESTER MACHINE TOOL WORKS, ROCHESTER, N. Y.

sufficient pressure of steam to keep them going, about fifteen minutes in all being required to get steam up to one hundred pounds per square inch. The engine is made in various sizes from one horse-power upward, and the marine type is essentially the same as that here shown, a few modifications being necessarily introduced to adapt it to its special work.

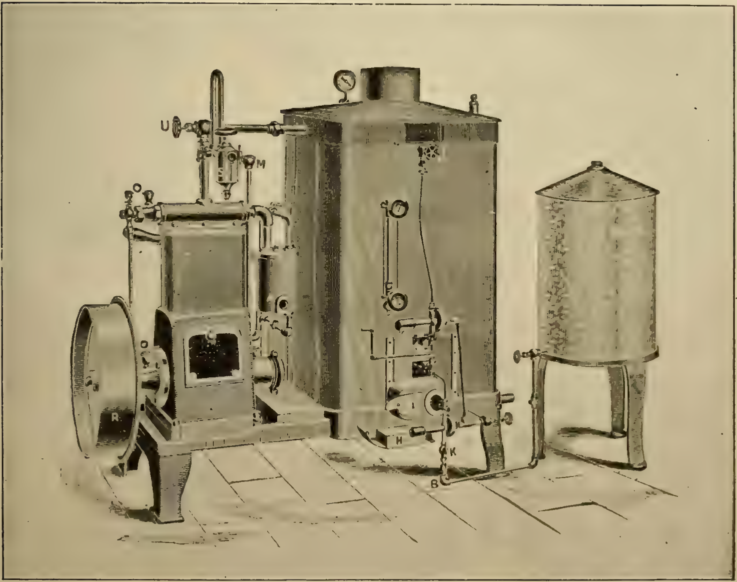
The Acme engine, another one of the type here considered, and shown on this and the opposite pages, is a double-cylinder, single-acting motor, with pistons sufficiently long to form their own guides, and, hence, dispensing with piston rods and crossheads. The valve in this engine is of the balanced, rocking kind, and is placed on the top of the cylinders, the valve case forming the cylinder heads.



THE ACME BOILER.

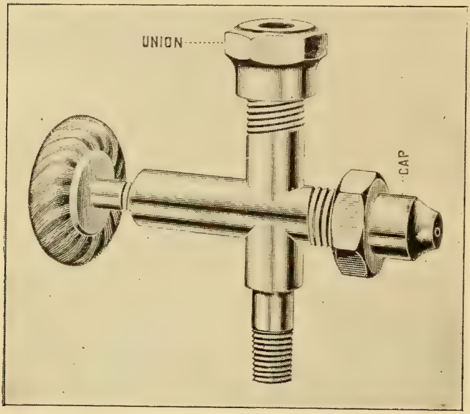


THE ACME STATIONARY ENGINE.



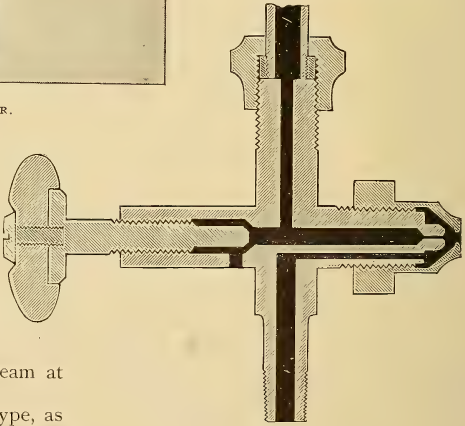
THE BRYANT ENGINE AND BOILER, BUILT BY THE WHITMAN & BARNES MFG. CO., SYRACUSE, N. Y.

The governor is carried within the flywheel rim, and in this case, too, directly controls the eccentric and valves, automatically adjusting the quantity of steam admitted to the cylinders to the amount of work to be done. Lubrication is accomplished by carrying in the crank case a mixture of oil and water into which the cranks dip at every revolution, thus not only being flooded themselves, but throwing the oil to every part inside the case. As this oil cannot escape, it is used over and over again. A hand pump is provided for filling the boiler when empty, and for furnishing a supply of compressed air when getting up steam at the start.



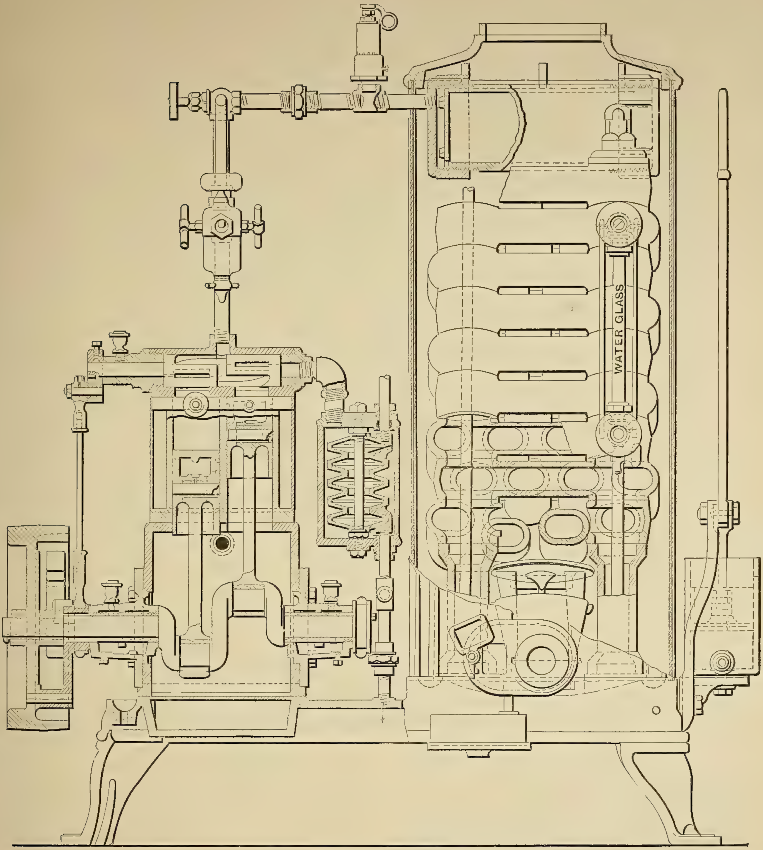
THE ACME ATOMIZER.

The boiler is of the sectional type, as will be understood from the illustration on page 98, and a large ring on its top serves as a dome and settling chamber for separating the mechanically entrained water from the steam. A drawn steel tube or water column extends up through the centre of the boiler, and into this the several sections are securely fitted. A steel bolt passes through the column from top to bottom, and firmly holds in place the caps closing the upper and lower ends. The column, it need perhaps scarcely be pointed out, provides an ample water space in the centre of the boiler, and gives each section a free circulation of its own. The feed water goes to the boiler, first through a pump, worked directly from the main shaft, and then through a coil heater, where it takes up some of the heat of the exhaust steam from the engine. The supply of water to the pump itself is regulated by a ball float in a case attached to the boiler, a constant relation being thus maintained between the amount fed in and the amount evaporated and supplied to the engine in the shape of steam. A fire regulator, on the other hand, controls the oil supply to the furnace through the atomizer according to the prevailing demand for steam.



SECTION OF THE ACME ATOMIZER.

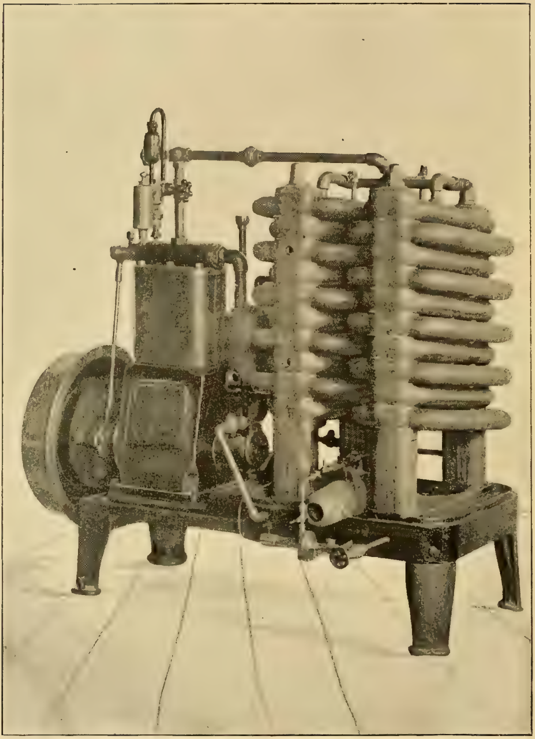
The arrangement of the atomizer is clearly shown in the two views on this page. By turning the wooden handle of the rear plug the latter is removed from its seat and any water of condensation which has accumulated in the



VERTICAL SECTION OF THE BRYANT ENGINE AND BOILER.

steam passages may be blown out into the air. This accomplished, the plug is screwed down and the steam, entering from above, will issue through the nozzle at the right and carry with it the oil coming from below, the sprayed mixture entering the fire tube in the boiler, where it is ignited by a small torch. The oil delivery from nozzle can be regulated to some extent, independently of the action of the fire regulator already mentioned, by screwing the atomizer cap in or out, and heating of the oil before being sprayed is, in a measure, secured by the arrangement of the oil and steam passages, the former, it will be noted, running side by side with the latter for a short distance.

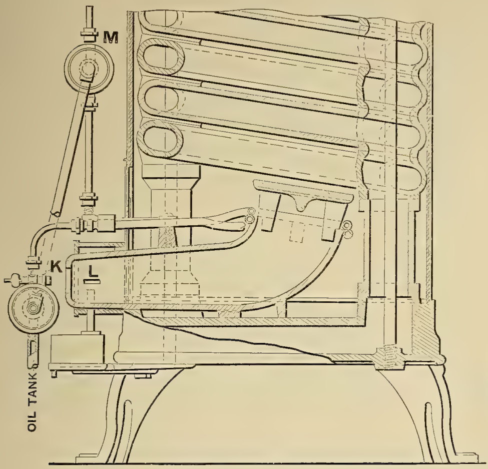
Another double-cylinder, single-acting engine, similar in a number of respects to that just described, is the Bryant motor, of which several illustrations, both sectional and perspective,



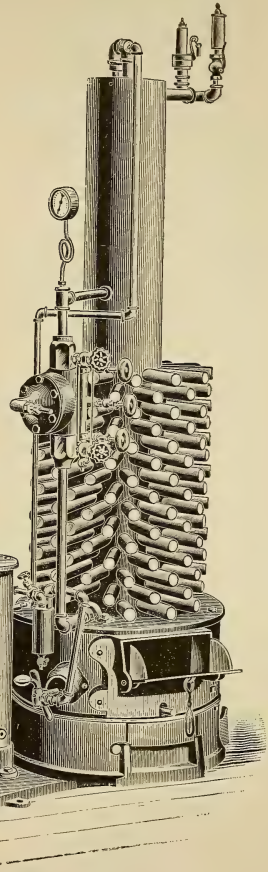
THE BRYANT ENGINE AND BOILER WITH CASING REMOVED.

are given. The same box design for the engine proper has been adopted in this, the method of lubrication of the internal working parts is similar, and the valve, also, is of the rocking type and is placed across the tops of the cylinders and is controlled by the governor. An exhaust steam heater, too, is employed for the feed water, being shown between the engine and boiler, its internal construction being clearly explained in the sectional view. The feed pump is driven from a small eccentric on the main shaft. The oil is driven through the atomizer K, shown in the small sectional view of the lower part of the boiler, into the combustion tube L by a jet of steam which is controlled by the steam regulator M. Both this regulator and an oil regulator operate so as to cut off the steam and oil supply when the pressure in the boiler has reached a certain degree, and again turn it on when the boiler pressure decreases, thus maintaining the pressure within a narrow margin. The main features of the boiler, which, like those already described, is of the sectional type, are clearly apparent from the illustrations and make detailed explanation unnecessary.

Still another engine, known as the Racine, remains to be mentioned, a marine outfit of this type being shown on page 104. The engine proper is built in two styles, the smaller sizes being a double-connecting rod engine. In this the piston rod is made of much greater length than usual, and, instead of having the customary cross head, it is extended downward to a tubular guiding sleeve in a horizontal cross bar, which is cast solid with the frame of the engine. The two connecting rods transmit the motion in the usual way, there being one rod on each side of the guiding cross piece. In the larger outfits a regular automatic engine, with the usual cross-head and guides, is used. Lightness and rapid steaming capacity of boiler are secured by the adoption of what has become familiarly known as the porcupine type of boiler, consisting essentially, as one of the illustrations shows, of a main, central, upright column with welded ends, the upper part of which serves as a steam dome, while from the lower part pipes radiate in all directions. An exhaust steam feed water heater is used in this outfit also. An atomizer, as usual, sprays the oil into the fire-box, which latter is fitted up with deflecting plates after the manner shown in the small illustration on this page.

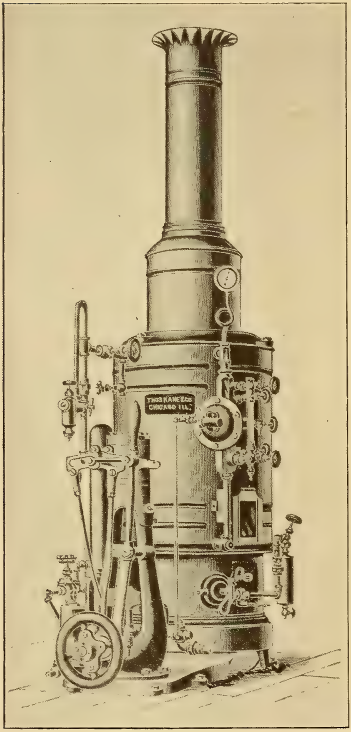


A BRYANT BOILER DETAIL.

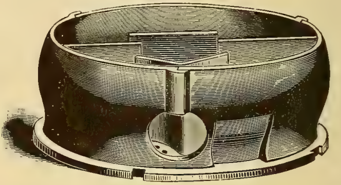


INSIDE VIEW OF RACINE BOILER WITH JACKETS REMOVED.

All the engine outfits here described are made in various sizes from one horse-power upward, sizes from one to four horse-power predominating, and all of them combine in their make-up the several features of automatism referred to earlier in this article. Safety, a very important requisite in power installations of this kind, which, from the nature of the service for which they are intended, must in many instances be entrusted to unskilled attendants,—has been provided for in the best possible manner. The oil fuel itself carries with it no more danger than that attendant upon current household use of kerosene, and this, of course, is so slight that it might be left almost entirely out of consideration. The danger always accompanying the use of a steam boiler, on the other hand, has been reduced to a minimum by the adoption of sectional types of boilers, so that, even with careless management, disastrous explosion would be out of the question. The crowning safeguard, however, is the much-mentioned automatic working character of the whole apparatus. The fire takes care of itself, and the water level in the boiler takes care of itself, and the engine proper is so simple and substantial that the engineer need really be little more than any one capable of opening and closing a steam valve for starting and stopping, and of working an ordinary hand lever air pump for a few minutes for starting the fire and getting up enough steam to work the oil atomizers. The outfits, in fact, almost directly exemplify, with slight modification, the now much-used catch-phrase, "You press the button; we do the rest."



THE RACINE ENGINE, BUILT BY THOS. KANE & CO., CHICAGO, ILL.



FIRE BOX CONNECTED.

AN ENGINEER'S VIEW OF THE MONEY QUESTION.

By A. F. Nagle, Consulting Engineer.

"WHEN doctors disagree, who shall decide?" When bankers, financiers, business men and legislators disagree so greatly on the money question, an engineer may be pardoned for devoting a few thoughts to this interesting and complex subject.

What is a dollar? In nearly all our business transactions we pay, or receive pay, in what is popularly called money, but which is really only a representative of money, more correctly called currency. This currency consists of various kinds of notes, and by examining their faces and backs you can find out exactly what they are good for and what they are not good for, but you will observe that each of these notes promises to pay to bearer on demand a dollar, without specifying what a dollar really consists of.

Many people believe that the Constitution of the United States has established gold and silver as the money of the country, but all that the Constitution says on the subject of money is (Article I, section 8), "The Congress shall have power to coin money, regulate the value thereof, and of foreign coins." In pursuance of the power granted it, Congress has established a gold and silver dollar, each of a certain weight and fineness, as the money of the country. From a legal standpoint Congress can give these coins (a coin is a piece of metal stamped by the government) any value that it pleases, and it can also make any number of metals money metals. But is there not a rational, perhaps a scientific, hence definite and clear solution to this subject of money rather than one left to the uncertain and arbitrary action of Congress?

An engineer is so accustomed to the use of and necessity for standards of all kinds that he naturally looks for a standard of value. This standard, however, unlike other standards, cannot be of an arbitrary nature, but must be one concurrent with a value established by trade laws, that is, trade has found the value and it can become a money standard among all nations who agree to its adoption. True money is cosmopolitan in its nature. It should be "without a country" because good in all countries with which we have trade relations. Each country can make its own money standard, if it chooses to do so, but if it does not agree with the standard of other countries, its money metal would be a commodity—that is, of fluctuating value, subject to trade laws, like other metals—in the country not a party to the agreement.

It is a fact that gold is the money metal of nearly all civilized countries, certainly of nearly all countries with which we have trade relations. It does not matter whether these gold coins be called dollars, pounds, napoleons or ducats, their relative value is in exact proportion to the weight of pure gold which they contain. Now what gives gold its value? Gold obtains its value in exactly the same manner as all other metals do, namely, through the laws of trade. All that governments do is to stamp the metal and call it by certain names, as guarantees of its being of a certain weight and purity, or fineness. It would have been just as well, and less confusing to most people, if the word dollar had not been invented at all and the weight of the coin (23.3 grains, or say 25 grains of gold) had been the unit of value.

There comes in, however, this peculiar result, namely, that the moment a certain weight of gold is made the standard of value, its value cannot change any longer, as it did when it was a commodity. This fact is not generally understood, and I will endeavor to make it clear. Practically a gold dollar is gold bullion and, hence, always ready for manufacturing uses; and on the other hand "old gold," that is, discarded articles of trade, made of gold, is always worth its bullion value, ready to be coined into gold dollars. Thus there is absolutely free interchange (without loss to the holder), between gold dollars and old or new gold bullion. The only thing that government does is to stamp the gold, thereby certifying to its weight and fineness. Thus we see that gold dollars are made in two ways—from newly mined ore and from "old gold;" and articles of gold manufacture are also made in two ways, from gold dollars and from bullion, old or new.

No law of Congress can prevent this free change of form of gold, and hence we see that gold dollars are made from the surplus stock of gold not yet worked up in the arts. This surplus stock is increased or diminished in different ways, but its value remains the same as long as there is sufficient to answer the purpose of money metal. But what can increase its value? When the surplus stock is worked up in the arts, or is so greatly drawn upon, that so small a quantity remains as to be insufficient for money uses; when this happens, and a new standard has been adopted, then gold will become a commodity and its price will be increased. There is another way in which gold can become extinct for money purposes. If it "did not pay" to mine gold, the supply being exhausted and the consumption in the arts going on as before, gold dollars would be constantly melted up until the scarcity would be felt, and the government would have to provide some other standard of value, and again gold would become a commodity, and again its price would be regulated by the supply and demand.

Another hypothetical case can be taken to illustrate the law, how its value could be diminished, or even destroyed. Assume that gold ceased to be wanted in the arts, indeed, that nobody wanted it any longer for any purpose, and yet the supply by the miner went on as before, and all "old gold" was melted up and coined into dollars, then what would a gold dollar be worth? Not as much as a grain of corn. On the other hand, assume the consumption to remain as before, but that gold should be found in such large quantities and with such small amount of labor that the artisan should abandon his bench, the farmer his plow, and the domestic her dishes, because each could make a fortune in a day by turning miner, what would a gold dollar be worth? Surely not a bean, for all other work would be abandoned for gold mining.

Thus we see that gold can be used as a money metal only as long as the ratio of its consumption in the arts to its supply from the mines be kept within reasonable limits of fluctuations, and while it remains within these limits its value cannot change one iota. It is perhaps well to add that a metal being used as a money metal, that is, as a standard of value, free coinage is implied therewith. If free coinage does not exist, then the metal is a commodity and has fluctuating values which unfit it for money. I think it is plain from the foregoing reasoning that no fault can be found with a single standard of value, gold, if there be enough of it to answer the purposes of business.

Precisely the same reasoning that has been applied to gold as a single standard is applicable to silver if used as the exclusive money metal. Gold would then be a commodity and silver would be stable, or unchangeable, in value, under the conditions illustrated. If its legal value were about the same as its real value in the arts of trade, it could maintain itself as a money standard, but if the demand for it in the arts should diminish, and the cost of production become very cheap, then there would be a flood of silver and fears would spread that it was not worth what it pretended to be, and with this state of things, continued to its logical conclusion, silver would soon have no value at all. So again, if the demand in the arts increased and the cost of production also increased so greatly as not to pay, then the stock of silver dollars would be gradually melted up and silver would cease to answer the purpose of money metal. A new metal would have to be selected and silver would become a commodity, when supply and demand would adjust themselves through change of prices.

We have seen that we can have either a single gold standard, or a single silver standard, each, however, only under certain favorable conditions. Can we not have both? Yes, if all the nations with whom we have trade relations also adopt them, and each metal be able to maintain its position precisely as if only one metal were used, in the manner and under the conditions already pointed out. But why have two money metals? Only upon the assumption that one metal would not supply sufficient money. The amount of money required depends upon the volume of trade within a given time. It is probably indisputable that gold alone would not furnish sufficient money if all our large business transactions were upon a cash, or C. O. D. basis, but modern financiers have provided a representative of money, called currency.

Currency is notes issued by individuals, corporations or governments, which promise to pay a certain number of dollars, and in this manner a large volume of business can be transacted without the actual transfer of gold dollars. Instead of making these notes redeemable in gold, it has also been found that other "valuable considerations," equal in value to gold, such as government bonds, mortgages, etc., can be used as security for the "promise-to-pay" notes. These notes perform all the functions of money as long as they are as good as money, that is, if they can be transformed promptly into gold or other equally valuable property.

Then again, modern banking has devised methods of book-keeping and accounts by which it is not necessary to make payments of debts directly in currency, or money, but by checks, drafts, and clearing houses the actual transfer of money and currency is again reduced to a minimum. So we see that while the volume of business transacted in a country, or in the world, may be large, the actual amount of currency and money required to do that business may be quite small. The actual amount of money, gold or silver, available for many purposes is entirely beyond the control of governments, but to provide the necessary amount of currency is the proper function of government. What this currency shall consist of, I do not intend to discuss.

Under our present policy toward silver, it is a commodity, and hence not money. It can only be made money by free coinage, upon a valuation acceptable to, and adopted by, all nations with whom we have trade relations, and at the same time it must be a valuation concordant with its true value in the arts, precisely as if it were the single standard and able to maintain its position as such. At present, as a commodity, silver helps to provide a currency redeemable in gold. But is it not an expensive currency? Would not a "note" of some sort, also redeemable in gold, be precisely as good? In fact, would not the note be preferable, costing but a fraction of a cent while our silver currency costs fifty-eight cents per dollar? Both silver dollar, so-called, and note, must be redeemable in gold dollars, or we would instantly fall to a "silver basis." No one at all familiar with financial laws disputes this fact, and hence, there is a public pledge by both political parties "to maintain silver at a parity (equality) with gold." But what folly to attempt by force of government to set aside the laws of human nature as exemplified in trade laws? Experience having shown us that the silver contained in our silver dollar can be produced at a profit at one-half of its face value, and experience also having shown that but very little difference can exist between the face and bullion value of a coin without unfitting it for money metal, how futile and unwise is the action of our Congress in this matter!

If the laws relating to a money metal, as I have outlined them, be correct, we can readily see why Europe abandoned the silver standard and also why we must do the same. It was one of those cases where the cost of silver production became so profitable as to bring about an excess of silver far above its consumption in the arts, and, being a money metal (free coinage implied, of course), its price could not diminish to check this excessive production ; hence, a deluge of silver was inevitable. To avoid this catastrophe, free coinage was stopped, which of course reduced it to a commodity, and then operating under natural laws of trade, its true value was soon found to be far below its face value. At the time that silver was demonetized, all valuations of property were upon one standard, gold and silver being one and the same standard. No change of values occurred, because gold was and remained that standard, silver simply being dropped out. Demonetizing silver, of course, reduced the volume of money, but financiers have learned to provide a currency by other ways than using silver as a commodity.

We hear a great deal about a conspiracy against silver. The position that silver has taken, from money to a commodity, is the operation of a natural law of trade, and no human statutory law could have avoided it. To attempt to restore it to a money metal when we do not need it as money, is against nature and cannot succeed. To use silver as a currency is also uncalled for, as has been shown in this paper.

Who is benefited or injured by the demonetization of silver? No one is benefited by the demonetization of silver. All valuations of property, including salaries and wages, remain precisely the same as before, namely, upon the unchangeable value of a gold dollar.

There is one party who is injured by the demonetization of silver, namely, the silver miner. He alone is injured, for if silver were not demonetized he could sell his silver for 100 cents where he now gets only fifty-eight cents. Of course, he sells this at a profit, or he would not mine it, but one can readily understand why he uses his political power to restore silver to a money metal.

It is unfortunate that the people who give these men political power do not understand this matter. One reason for the large following which these silver miners have is to be found in the present trend of sentiment among the people against the money power of the country. These people do not discriminate between the power and the value of money. They think that by attacking the gold dollar they strike the "gold bug," while the truth is that the "silver king" is as much their enemy (?) as any other large holder of wealth. Outside of these individual interests, we are all interested in maintaining the present gold standard, but to depict the harm that would result by changing to a silver standard, without the concurrence of the nations with which we trade, and upon a valuation of silver concurrent with its market value, would be outside the province of this paper.

It is frequently asserted that the fall in the price of silver was brought about by its demonetization, and that a like fall of price in gold would take place if it were demonetized, and that this was a conspiracy to make gold dear. It has already been shown that silver was demonetized for valid reasons, grounded on trade laws, and that it was simply inevitable. Its continued fall in price has confirmed the wisdom and necessity for its demonetization. It is not worth what it pretends to be, and hence it was unfit for a money metal at the valuation put upon it by statutory law. If gold had been subjected to the same influences as silver has been, it would have had to succumb and give way to silver, if silver had remained stable. But assuming that it was an arbitrary act, instead of a necessary one, and that gold should be arbitrarily demonetized by the United States, what would happen? There being no trade reasons for its change of value, it would not change its value one iota, and our gold would simply depart for Europe.

If all the nations of the earth should now arbitrarily demonetize gold, assuming another money metal to be satisfactorily substituted therefor, and also assuming that the position of gold in the arts had not changed, then gold, having become a commodity, would find its true value again. It would rise in price, after a temporary fall. If it be true, as has been asserted so often by good authorities, that it costs two dollars to mine one, and that it is only the expectation of getting two dollars at an expense of one that leads men to mine gold, then the price of gold would rise after becoming a commodity. Mining would cease, and the surplus stock of gold in the form of gold dollars would supply the trade for a while, but as no gold was being mined, the gold dollars would be held for a rise in price, which would be inevitable as the supply from the miners has ceased. If the gold dollar were really cheap, that is, if it cost less than a dollar to mine one, gold dollars would accumulate and bring about a change before it was demonetized and thus, soon after, compel its demonetization, precisely as silver money forced itself out of existence.

The fact that gold dollars do not accumulate very rapidly, nor disappear, is proof of their fitness, at their present valuation, for the standard of values. If they be hard to mine, it does not affect other valuations one iota, but only the miner who does more than a dollar's worth of work in trying to get one. If he should tire of this, and cease mining, it has been shown what the result would be.

JEARUM ATKINS AND HIS INVENTIONS.

By R. D. O. Smith.

THE period of American activity in invention dates from the enactment of the present patent law in 1836, fifty-seven years ago. Examine the product of say the first forty years, and note how many of the thousands of inventions patented during that period have endured until to day. Those inventions of that time which struck close to the root of physical principles can be counted almost on the fingers. Yet during that period the mechanic arts in this country made such advancement that we came easily to the front as inventors of practical labor-saving devices.

Among the power appliances most cultivated have been water wheels, and, among these, turbine and impulse wheels have naturally received nearly all the attention and have almost wholly crowded out the older types of vertical wheels, like the over-shot, scores of them having been patented. Unfortunately, however, many of them have yielded but indifferent results, and have represented simply a vast amount of study, ill-directed, and, in the main, unprofitable. It is, therefore, all the more interesting, even at this comparatively late date, to recall the fact that a wheel of the best grade was invented as long ago as the year 1853, though, it is true, a patent for it was not obtained until twenty years later.

Jearum Atkins, the inventor of this early wheel, and a mill wright by trade, was, in truth, a mathematical genius, developing for himself at an early age, alone and unaided, not a few of the intricate processes of higher mathematics, solving, among other things, by experiment, the problems of the flow of water through orifices which made Venturi famous.

From such a mind, inventions could hardly come without having passed through the crucible of scientific test. Somewhere about 1840 he devised a water wheel planned to absorb all the momentum of the moving stream and he was able to demonstrate in advance the physical results which were afterward justified by experiment. But when, in 1853, he laid this invention before the Patent Office the examiner was not able to comprehend it and it was rejected. Being then a bed-ridden man, owing to spinal injuries inflicted by a runaway horse, the application was not pursued, but twenty years afterward it was again presented with matured details of structure, and a patent was issued on August 10, 1875. Since that time the invention has been public, but its merit has not been recognized and the patent has expired without a wheel having been built.

The writer does not propose to discuss the mechanical or theoretical value of this invention further than to suggest that while for the enormous pressures under which the Pelton wheel acts the round nozzle and free jet may be a preferable form, it does not appear to follow necessarily that the Pelton wheel is theoretically a more perfect form than the Atkins wheel with its semi-circular buckets, confined water and rectangular jets under low pressure. The advantages of the Pelton wheel may be quite dependent upon other considerations, viz., the absence of enclosures and joints capable of withstanding enormous hydraulic pressures, and the absence of friction incident to close fittings capable of withstanding such pressures. It would seem to the writer that the Atkins wheel approaches theoretical perfection as closely as human mechanisms ever approach it, and that the Pelton wheel is a wonderfully successful adaptation of Atkins' discovery to special circumstances.*

However, to return to Mr. Atkins himself. At the time of his birth in 1815, and for some years after, his father owned a small sawmill, and to this circumstance is due his early attention to studies in connection with hydraulics. In those days good schools were few and far between, and the children of all but the specially favored few had scant opportunity to avail themselves of even such indifferent schooling as was provided. His school training, therefore, was comprised in a few short winter terms, and did not extend beyond the old fashioned three R's. With the last of these—"rithmetic"—he was always at home, and this, with his love of mechanism, absorbed his youthful ardor. Before he was ten years old, with no tools except his Yankee jackknife and perhaps a file and gimlet, he constructed a miniature sawmill, complete in all its details, the iron parts of the real mill being supplanted by pewter in the miniature. Many boys of ten have built miniature sawmills, but this mill, owing to its perfect scale and workmanlike finish, was a marvel in all that country side.

When about fifteen years old, in pursuit of knowledge on the only plan possible with him—original investigation—he made a series of experiments on the flow of water through orifices, duplicates of those experiments which, as already stated, made Venturi famous, and this performance, to which he did not attach any great importance, was only one of many. In fact, physics and mathematics were his passion, and as books were not accessible, the discoveries of others were a sealed volume to him, and he naturally turned, as other ardent and curious boys do, to devices of his own to satisfy his curiosity. About this time an old volume on astronomy fell into his hands, and he found out that, though not familiar with the higher mathematics, he could yet compass and understand the reasoning, and by original methods reach the results given. He says that he was never defeated by any mathematical problem.

In due time he went with an acquaintance to learn the trade of millwright, but was operating on his own account before he was twenty-one years of age. Shortly after arriving at his majority he removed to the West, and remained in Chicago and vicinity until about 1866. To a man of his skill and intelligence all roads lead to Rome, but one unfortunate day he was thrown from his wagon by a runaway horse and suffered spinal injuries, from which he did not recover for more than

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☞ * The Atkins wheel of 1853 is described in this issue by Mr. John Richards in an article entitled "Tangential Water Wheels."

twenty-five years. During those years he traveled from Illinois to New England to obtain medical advice, but without avail, his life being twice despaired of during this period. One physician with grim humor told him that nothing but his obstinacy carried him through.

The helplessness of his body probably but served to intensify the activity of his mind. During most of these years of suffering his home was in Evanston, Ill. He rigged up a drawing board, suspended face downward, above his head, and with a T square, movable but permanently attached to the board, he worked out a great number of intricate and ingenious problems. The drawings made by him under these adverse circumstances are marvels of neatness and accuracy. Most of these have never been made public in any way except by exhibition to friends, and many of the inventions that he so laboriously worked out will die with him. During all this time he not only supported himself, but he also acquired a handsome property.

One invention of the early years of his prostration brought him fame and some money, but was destined to ruin him in the end. This was a self-rake harvester, in which the rake moved with a continuous progressive motion derived directly from the rotation of the master wheel. Prior to that time the self-rake was known as the reciprocating rake, and its action was violent and unsatisfactory. Atkins' patent was numbered 9479, and was issued on December 21, 1852. Space will not permit a detailed description of this machine, which, as a new mechanical movement has few superiors in ingenuity. John S. Wright, editor and proprietor of The Prairie Farmer, secured a half interest in the patent in consideration of his undertaking to manufacture the machines, and a considerable number were made and sold. They were exhibited at county fairs all over the West and received medals, cups, premiums and diplomas enough to fill a good sized trunk. Lying upon his bed, Atkins constructed, of mahogany and steel, a model of this machine, which has traveled many thousands of miles in this country, and has been exhibited even in Europe. It is still in existence. Several old farmers have assured the writer that none of the more modern machines worked more satisfactorily than the Atkins machine of that time. The success which attended it warped Wright's judgment. In opposition to Atkins' advice he made a number of contracts to build the machines on royalty, and of those so built nearly all were returned to the makers by reason of careless workmanship and the use in them of green timber. The reputation of the machine was spoiled and the makers were ruined. Wright was unable to go further, but refused to relinquish his interest, and finally became insane.

Shortly before the expiration of the harvester patent, Mr. Atkins was in a measure restored to health, so far, at least, that he has ever since been able to walk about. He went to Washington to procure an extension of the harvester patent, and the Commissioner of Patents at that time pronounced his application the strongest which had ever been presented, and promised that the patent should certainly be extended. This promise, however, was not fulfilled. Mr. Atkins then petitioned Congress, and finally, after three years, was granted an extension of the remainder of seven years. He then was informed, on what he considered good authority, that the harvester manufacturers had combined to fight the patent, and on the advice of friends, among whom was Ben Butler, he petitioned Congress to pay him $100,000 and give the invention to the public. The writer regrets not having at hand a copy of the memorial in which Mr. Atkins cited several precedents for the action prayed for, and demonstrated the patent to be a public benefit fairly estimated at hundreds of millions of dollars. Unfortunately for him, however, while the justice of his claim was appreciated, he could never work his bill through both houses of Congress before expiration. He has year after year asked Congress to grant him a just return for benefits conferred.

In that supreme effort he has laid down his possessions, and old, blind and in penury he will soon lay down his life.

Between times, in Washington, he patented several ingenious inventions, but, as he has often remarked, he was born to misfortune. His inventions were all too large to be handled with small means, and capitalists are never satisfied with a moderate share. He brought out an ingenious mechanical movement called a governor for fluids under pressure in the Letters Patent, dated March 30, 1869, No. 88,431. The effective member was a piston balanced in a fluid under any desired pressure, the influx and efflux of said fluid being regulated by a small balanced valve controlled at will. The interesting feature of this device was found in the fact that the port was opened by a movement of the valve, and closed by a movement of its seat. One practical application of this invention was to a ship steering engine, which was worked out with Atkins' accustomed elaboration but has never been patented.

The same mechanical movement occurs in the patent No. 85,779 for a marine governor, in which the balls are only about of one-ounce weight, moving in and out on a straight line and designed to be speeded so high that their small gravity would be practically undisturbed by the motion of the ship. This invention he sought to introduce in the navy, and after many fruitless efforts to overcome naval conservatism, he finally approached W. W. Wood, chief engineer, and Capt. Patterson, then head of the Coast Survey, who promised him a trial, but before it could be brought about both died.

During 1868 and 1869 he patented, besides the above, a farm gate, a harvester cutter, a safety valve, a locomotive smoke stack, calipers, and a low water alarm, all of them evincing a profound knowledge of mechanical and physical laws. He also made several other applications for patents, which failing fortune compelled him to abandon. Among the inventions which were worked out, but not patented, was a method of loading heavy guns, designed particularly for use on the monitors, which were then supposed to be the acme of naval architecture. It was well known that the work of charging one of the big guns on these vessels was no child's play. The deck was awash and the gun could not recede far enough to make it possible to ram home the charge from within the turret. Atkins' plan was to drill a small hole through the breech of the gun, protect the same with a suitable internal valve and gas check capable of being opened from without and by a suitable pipe to connect the bore of the gun with some air exhauster; then, the charge having been placed in the muzzle of the gun with an air tight plug in front, the air was to be exhausted from the breech, leaving atmospheric pressure to ram home the charge. This revolutionary innovation received no countenance from the ordnance authorities of the Navy Department, though Commodore Dalghren, who was then in command of the Navy Yard at Washington, regarded the invention as of the highest importance and promised to have a gun fitted at the Navy Yard. Death, however, overtook him. Then a gentleman who had acquired some reputation as a promoter and lobbyist proposed to take the invention to England. The working model was entrusted to him and Atkins has never seen either man or model since.

Thus has passed the life of one upon whom nature showered great gifts, but whom relentless fate has pursued almost to the grave. For years Mr. Atkins has lived in poverty, relieved by the transient good offices of friends and by the use of his pen to a limited degree, partial blindness restricting his ability to write. About eight years ago he suffered a stroke of apoplexy, and more recently a street accident permanently deprived him of sight.

INDIFFERENCE TO BOILER FIRING AND MANAGEMENT.*

By Daniel Ashworth, Mem. Am. Soc. M. E.

OBSERVATIONS extending over a period of a quarter of a century in a practical and professional way have presented opportunities to note, in the greater number of manufacturing establishments, a continuous decline in the grade of service of those in the positions of firemen and boiler room managers, this corps of operatives seeming, at least, to have remained in *statu quo*. The evil has become so glaring and the results so palpably fraught with disaster, destruction and waste as to warrant an effort to call the attention of those who desire to progress, to the false and inconsistent position which they occupy by permitting such a narrow policy in management, so widely at variance with true economy, ignoring directly that the better intelligence renders the more valuable, and, hence, more profitable service.

It goes without saying that, during the past ten years, the concentration of efforts by scientists and eminent mechanics looking to the more perfect development of the steam engine in its various types has produced results which challenge the admiration of the most critical in this line of thought. Within the same period, from every source, there have been a multitude of features in the form of designs and novel applications of boilers, all converging to the important factors of increased economy, efficiency and safety. In the engine sphere, condensing, compound and triple expansion engines, with and without jackets ; in brief, seemingly, all the necessary refinements have received and are now receiving close attention. In the boiler domain there has been also the evolution from the plain cylinder type to the tubular, and from that through the multifarious forms of water-tube designs, each striving for a superior degree of excellence. The amount of research and practical application that have been and are being instituted in attempting to increase efficiency and economy, is such as to be incalculable. A retrospect of the past, viewed in the light of present results, shows that these efforts have been of an exceedingly fruitful character.

The development has carried with it the imperative advancement of those in charge of engine management to such an extent as to create almost anew this body of men. Such an intellectual advancement in the department of mechanics, the writer believes is without precedent, and in every sense challenges admiration from every quarter. Notwithstanding these favorable features, we are constrained to say that all this is somewhat like the play of Hamlet—with Hamlet left out; or, in other words, we are radically defective at the very threshold of this field, by reason of relegating the firing of boilers to the most ignorant of operatives ; or, to put it in a plain way, there seems to be an almost unanimous idea that any one who can shovel and throw fuel is good enough for a fireman. Close observation and contact for a period of years, with numerous plants of varied character, increase the conviction of the writer upon this point. Recognizing, as we all do, that the furnace of the boiler is the prime feature and great initial point from which comes the source of power, does it not properly follow that if economy and efficiency are deserving of efforts in the advanced stages, as has already been pointed out, this is the very point that should be treated with every consideration of intelligence? Should not the fuel, furnace and boiler receive the thoughtful attention that the engine receives from the careful engineer? I think this will be accepted by every one interested in advanced ideas. No one, I think, will question the fact of the importance of the initial point of the boiler and its furnace, and that with mismanagement these other efforts of refinement are rendered, in many cases, completely void. It would seem so simple that argument would be unnecessary, were it not that on every hand the matter is entirely ignored, resulting in waste and destruction. We would ask—are not the efforts of the best furnace designers often completely set at naught by reason of the manner in which they are operated? Is it not a glaring fact that in all cities where smoke abatement has been and is being attempted, the great stumbling block is the low grade of intelligence and low grade of the boiler operatives?

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* From advance sheets of a paper to be read before the Engineers' Society of Western Pennsylvania.

In looking upon this subject from a mechanical and engineering standpoint, we are fully alive to all the requirements to give complete combustion and thorough distribution of heat units, proportion of grate area and openings. Proper amount of air, conduction of the heated gases, are all carefully considered. When all is completed we have the wonderful spectacle of these conditions being turned over to the simple treatment of ram-jam shoveling and slice-bar operations. I claim that the fireman should know, at least, the elements of combustion, the importance of proper management of fires to produce the greatest results with the least expenditure of fuel. It may be said that the application of mechanical stokers makes intelligent firemen unnecessary, a point that is frequently (and I believe without thinking) claimed by those interested in placing such stokers. This is a great mistake, well known by those conducting tests, the results always being superior with the greater intelligence of the operator of the machine.

Within the past few years, in every community where cleanliness, taste and health are considered, there has come forth a crying appeal to the authorities to lessen the great evil of smoke in the atmosphere. In response to this, inventive genius has promptly come forward. The multitude of devices that have been perfected and put in operation furnishes ample testimony of this fact. Many of these, when properly operated, accomplish satisfactory results in smoke abatement, but no inventor has ever had the temerity to label his machine or furnace, "No skilled fireman required." Per contra, it is well known that the most intelligent fireman produces the best results, and it is also an undeniable fact that the best devices are set at naught by incompetent operating. The writer has been brought in contact with large fields of boiler practice, and in many cases, aside from other disqualifications, the firemen were unable to speak or understand a word of the English language. It may be said, as I have heard it said, that these men are not paid to think, but to do. Well, they do do. They will "do up" a coal pile, furnace and boilers with alarming rapidity. I say alarming to those whose views are broad enough to consider the initial and important points. On the other hand, it is a lamentable fact that there are a great number of men in official positions, as superintendents and proprietors of establishments, who seem to be utterly incapable or unwilling to note the importance for the necessity for a higher grade of labor in the firing and management of boilers.

One of the most surprising features in connection with this state of affairs is the tendency of those interested to place boilers claiming, among their numerous merits, that less attention is required for them than for others, precisely on the old exploded claim applied to engines, "No skilled engineer required." I have now before me a letter from a boiler representative, who claims that his boiler will give the utmost satisfaction with one-half the attention that others receive.

What is greatly needed at present is to lay aside the idea that any one is good enough to fire and manage boilers. When you engage a man for your office do you not require that he shall possess some qualifications for the position, and if aptness is shown do you not show appreciation by advancement to a higher plane, the interest being mutual? Why not apply this to the selection of firemen? As it now stands we cannot but exclaim, "Strange, what a difference there should be twixt tweedle-dum and tweedle-dee!"

There are many plants in operation where, by incompetency in this line the steam efficiency is greatly lessened, furnaces and boilers are working in neglected conditions, fuel is wasted and the community is begrimed with volumes of unnecessary smoke. In addition to these evils, lives and property are jeopardized. Unless this matter is considered and such action taken as will improve this corps of operatives, it would seem absurd to be continually reaching and extending into the higher refinements of steam engineering. Under these conditions do not the pertinent questions present themselves to the employers: Are we not occupying a false position by this indifference? Do we not retard the development of a class of labor which, by a recognition, by an appreciation, that some skill and judgment are required, would be animated by some spark of ambition to qualify for advanced positions? Is not this condition of affairs a gross inconsistency, nay, a mockery, in the face of the query put by those guilty of this indifference.

Why can we not get better men than this? In reply to that I would say simply, it is not sought on your part. Just as long as this class of operatives is looked upon as mere shovelers, throwers of coal and carriers of water, ignorance, with all its attendant waste, destruction of property and general demoralization, will be prominent in the boiler department.

A FEW FACTS ABOUT ELECTRICAL FIRE HAZARDS.

By W. H. Merrill, Jr.

IN endeavoring to impress upon fire underwriters the importance of training inspectors in matters electrical sufficiently to give them as much knowledge of the fire hazard of electricity as they now generally have of that of oily waste, or gas jets, or rubbish, the writer, at the last annual meeting of the Fire Underwriters' Association of the Northwest, maintained that any agent of an insurance company who is competent to determine fire hazards other than electricity, is capable, with a little study, of correctly interpreting the standard code of rules of the Underwriters' International Electric Association. These rules are full and specific in statements of just what constitutes the fire hazard in all electrical apparatus.

Take, for example, the case of the arc lamp and its sparks : Here we have a small spluttering fire used for lighting purposes in insured property. Very well, treat it as such. Put a glass globe around it and have that globe securely fastened upon a closed base. Don't drape it with ribbons and laces. If inflammable material is near it, have a wire netting around the globe and a spark arrester which will close its principal orifice so that it will be impossible for any sparks thrown off by the carbons to escape. Fix it so that the carbons cannot drop out of the lamp. Many fires have been caused from sparks from arc lamps, carbons falling from arc lamps, broken globes not being replaced and artistic decorations being suspended on or near the lamp. Could not some of these fires have been prevented if insurance men would look at an arc lamp as a small fire rather than as a wonderful invention whose workings were hard to understand ?

A parallel to this case can be drawn for the mechanism of the lamp and its wires and connections, for motors, for dynamos, for heaters and for every piece of apparatus transforming mechanical power into electricity or electricity into light, heat or power which is on the market to-day. The most critical defects, from an insurance point of view, in all of them are manifest to any one who will give the subject a little attention. It needs, of course, more than this to see them all and realize their relative importance, but speaking generally, much can be determined by the layman. The electric motor with its starting device, the rheostat and its controlling switch have been responsible for a great number of the more expensive losses. The rheostat is the device used to throw a resistance into the circuit when the motor is started. Call it the throttle for the current, if you please. Now, a resistance introduced on the electric circuit transforms electrical energy into heat. Electric heating devices are constructed on this principle. Consequently the rheostat is a source of heat. If current is left on the rheostat it will make a first-rate stove. And yet electrical manufacturing companies design these devices and sell them enclosed in wooden cases and install them so that their coils will come in contact with wood and paper. The building occupant finds that they make good shelves convenient to the motor, and he keeps his oily waste, commutator vaseline, sand paper and odd rubbish on top of them until some one leaves the current on too long and everything burns up. Would this happen so often if every insurance inspector should look on these things as stoves and have them treated as such, rather than seeing in them only peculiar devices with peculiar names ?

TANGENTIAL WATER-WHEELS.

By John Richards.

THERE has arisen in this country, during recent years, an increased interest in, and a more extended use of, that class of water-wheels that bears the name of "tangential," "impulse" and "partial turbines," also sometimes called "open" or "free" turbines from the fact that the wheels are not enclosed, or submitted to pressure.

The name turbine, derived from tourbillon or "boiling," does not in respect to relevancy apply to the tangential or impulse class of water-wheels, but usage of it comes from the analogy in construction and application of impulse wheels, to pressure, or real turbine wheels. There is a clear line of division between the two, however, and present indications are that those operating by impulse are about to supplant, in many cases, the pressure types, especially when there is considerable water pressure, or for heads exceeding twenty-five feet. Reasons for this conjecture exist in the greater simplicity, reduced cost, and also higher efficiency, which is, or ought to be, attained with tangential wheels.

It is hard to account for the earlier and more complete development of pressure-turbine wheels, unless upon the supposition that scientific attention was especially directed to them from the beginning, and their somewhat intricate nature and complete adaptation as "first movers," created an interest such as always attaches to the new and mysterious. Scientific analysis has not, however, in forty years past, led to much uniformity of practice in constructing such water-wheels.

They are divided into types or classes varying greatly in construction and manner in which the water passes through them, but conforming in all cases to the distinct principle involved, which is the complete, or nearly complete, retardation of flow, so the "pressure" of the water is converted to turning moments, and then escaping in a state of rest.

This, the writer is aware, is not an expression conforming to mathematical analysis of turbine action, or to the commonly entertained opinion that the work of a turbine is a resultant of impact, reaction and pressure, but this does not matter; the premises to be derived from pressure-turbine action are not important in considering the impulse class of wheels so long as the spouting force of water is conceded as equaling its gravity less the friction in discharge orifices, and the losses of reactive discharge at divergent angles. It is on this latter law of spouting force or impulse, and without the least complication, that the principle of action in tangential wheels rests.

The impulse method of applying water as a source of motive power is unquestionably the oldest as well as the most simple, but in all early applications there was a neglect of what we may call the residual forces. Impingement took place on flat radial faces at various degrees of obliquity to these faces, and there was no provision for deflection, or release of the water, which spent a considerable part of its energy parallel to the axis of the wheel, or parallel to the faces of the vanes, at the same time clogging or retarding them.

In this country the earliest understanding of impulsive action, as distinguished from pressure in turbine waterwheels, seems to have been arrived at by Mr. Jearum Atkins, whose wheel is one of much interest, because, as the writer believes, anticipating the Girard or partial turbine form in Europe, at least in so far as manufacture is concerned.

Mr. R. D. O. Smith, of Mishawaka, Ind., who is well acquainted with Mr. Atkins and his discovery of the correct method of applying water to wheels on the impulse method, in a letter to this magazine says :

"Jearum Atkins is one of the most remarkable men ever born in this country. Nature endowed him with a phenomenal capacity for mathematical and physical inquiry, but did not endow him with means and opportunity. He was born in 1815 among the mountains of Vermont and learned the trade of millwright, but while yet a boy he originated and conducted for his own gratification those hydraulic experiments which gave fame to Venturi, and these were but a part of his early performances. Without knowledge of algebra he was never defeated by any mathematical problem. When a little more than twenty-one years old he was thrown from a wagon and his spine was injured so that he was bed-ridden for twenty-five years. During those weary years, stretched upon his back, and unable even to turn himself without help, he made a multitude of inventions and acquired a very handsome property. The drawings which he executed on a drawing-board, suspended above his face, are marvels of neatness and accuracy. His misfortune was, that his inventions were all too refined or too massive to be easily handled by a man in his condition.

"He was the inventor, among other machines, of the continuous rotation sweep rake for harvesters. This attracted more attention and was more widely known than any other agricultural instrument. It was extensively manufactured for several years, but bad business management ruined the manufacturers. A number of farmers who used the Atkins machine have assured me that none of its successors were equal to it. This patent was granted, I think, in 1852. About 1865 he recovered the use of his limbs, and as the patent was about to expire, he came to Washington to obtain an extension. He was then in possession of a handsome little fortune, but the goddess of that name was not with him. The then Commissioner of Patents admitted that Atkins' case was one of the strongest ever presented, and said that he would certainly extend the patent, but yet he did not. Then Atkins went to Congress, and after three years, got his bill through allowing the Commissioner to extend for the residue of seven years. Then he learned that the harvester men had combined to resist the patent, and under advice of such men as Ben Butler, he went to Congress for remuneration for the unrequited value of the invention. There he has been ever since. If Congress had endured for three years instead of two he would have succeeded, but he never succeeded in getting through both Houses before he would be compelled to commence again with a new House. For years he has been indigent, almost blind, and last winter he was thrown from a cable car and almost killed.

"Why should nature so richly endow one of her children and then fortune relentlessly pursue him through a long life?"

In another communication Mr. Smith says :

"Atkins' wheel was patented in 1875. The patent has now expired, and I am at liberty to say that the wheel was invented, built, tested and an application for a patent was made more than twenty-five years before that date. That application was rejected, just as this one was, because the examiner did not comprehend it. Atkins, then poor, had associated with him a capitalist friend who insisted upon abandoning the matter when it was rejected. All this may be ascertained from the records of the Patent Office Rejected Applications. Thirty years afterward he sought to recover something of this lost invention, and the patent above-named is the result.''

Engineers will be interested in the record of this early invention, and therefore the specification filed in the Patent Office, February 27, 1853, is freely quoted. The drawings, Figs. 1, 2 and 3, are copied from those which accompanied the application. The first clearly discloses the semi-circular bucket, channels and the scroll-shaped trunk. Figs. 4 and 5 are from the patent of 1875.

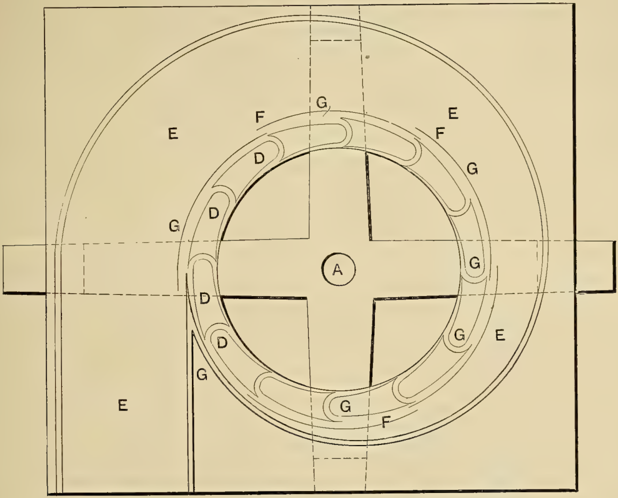

FIG. 1.—PLAN OF ATKINS' WHEEL AND WATER TRUNK, 1853.

''The nature of my invention,'' reads the specification, ''consists in so forming and arranging the various parts of the wheel and trunk that the water acts continually on all the buckets, approaching the wheel (as near as may be) in the direction of a tangent to its circumference. The water flows in smooth, unbroken sheets, acting by its centrifugal force against the semi-circular faces of the buckets, until it reaches their inner points next the shaft, when, having spent its force upon the wheel, it drops down through its open bottom and escapes underneath.''

After describing the mechanical structure, Mr. Atkins says: ''The important points to be observed in the construction of this wheel and appendages, are: First, that the gearing used to communicate motion from the wheel to the machinery which it is designed to operate should be so arranged as to allow the wheel's velocity at the axis of the buckets to be equal to one-half the velocity of the water at the point of impact, or where it issues from the mouths formed by the guides as described; second, that the aggregate width of all the channels or water passages between the buckets of the wheel, which may consist of a greater or less number, according to the size of the wheel or the amount of water which it is designed to use, should be equal or nearly so to double the aggregate of the mouths or water channels formed by the overlapping of the guides.

"As it is impossible in this specification to give the details of mathematical calculations by which I arrived at the results obtained by the before-described arrangement, I will only state some of the facts by which the maximum motion of the wheel, namely, one-half that of the water, is predicated, and also show the absolute necessity, in order to obtain the full power of the water, of the form of the buckets, and also their peculiar adaptation to the water trunk as hereinbefore described, in relation to the motion of the wheel. As the power of water, as of other bodies in motion, is measured by its velocity, or in other words, as velocity is power, it is obvious that in order that the moving water (or other body) may communicate its whole power to another moving body, the velocity of the former must be swallowed up in the latter.

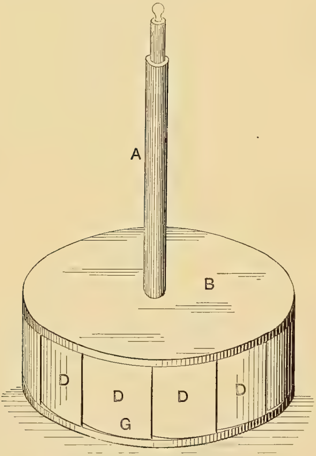

FIG. 2.—WHEEL DETACHED FROM TRUNK.

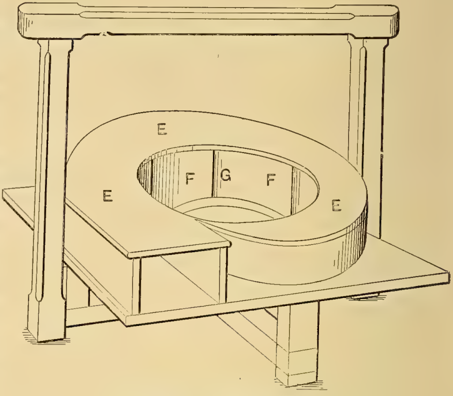

FIG. 3.—PERSPECTIVE VIEW OF TRUNK WITH WHEEL REMOVED.

This object is effected by the before-described mode of applying water to a wheel in the following manner, the velocity of the wheel, as before stated, being one-half that of the water. Let us suppose the velocity of the water to be twenty-four feet per second; then the velocity of the wheel being twelve feet per second, the relative velocity of the water with respect to the wheel, or the velocity with which it overtakes the wheel, will be twelve feet per second. Now it is proved theoretically, and also demonstrated by experiment, that water will flow over the entire surface of the semi-circular buckets of the wheel with the same velocity with which it first impinged against them, or twelve feet per second. Then, as the water in passing over the face of the buckets has described a semi-circle, and as its return motion on leaving the wheel is in an opposite direction from that of the wheel, its velocity with respect to the wheel being twelve feet per second, and as the wheel has an absolute velocity of twelve feet per second, it is obvious that the absolute velocity of the water with respect to a fixed point is entirely suspended at the moment of leaving the inner point of the buckets, its whole velocity, and consequently its whole power, having been transmitted to the wheel. If now we suppose the velocity of the wheel to be more than twelve feet per second, say sixteen feet per second, we shall find, by a calculation similar to the above, that the water will leave the wheel with a velocity of eight feet per second in the same direction of the wheel. On the other hand, if we suppose the velocity of the wheel to be less than twelve feet per second, we shall find that the water on leaving the wheel has a velocity in the direction opposite to the motion of the wheel, the measure of which will be double the difference between the velocity of the wheel and twelve feet per second.

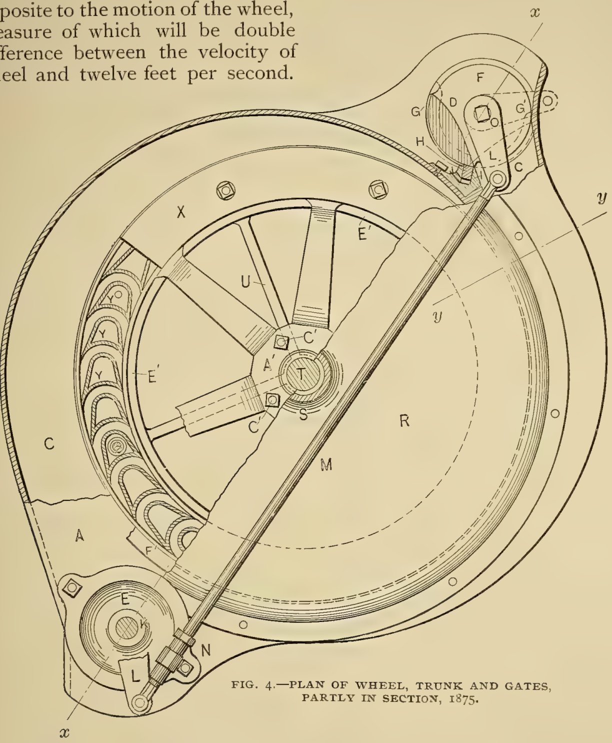

FIG. 4.—PLAN OF WHEEL, TRUNK AND GATES, PARTLY IN SECTION, 1875.

It is thus proved that when the wheel moves faster or slower than one-half the velocity of the water, there will remain in the water, after leaving the wheel, a certain degree of velocity and consequently of power, which has not been communicated to the wheel and is therefore lost, thus proving the maximum motion of the wheel, as above stated, to be one-half that of the water.

"I have stated above that the measure of the sections of all the water passages between the buckets of the wheel should be equal to double the measure of the sections of all the throats through which the water issues in its passage from the trunk to the wheel. The reason for this is obvious when we consider that all the water which issues from the trunk in a given time must pass through the wheel in the same time; and that the capacity of the channels through which a given quantity of water passes in a given time must be in inverse ratio to the velocity of the water."

Mr. Atkins, more than forty years ago, had thus arrived at a point in this branch of engineering investigation that not very many of the present day have reached, and much honor is due him for his researches, which if followed out at the time might have added millions of wealth to this country, and saved us from the humiliation of having to go abroad to find suitable designs for water-wheels to be employed at Niagara Falls, and for which none of our makers save one received any recognition by the commission appointed to examine plans for these wheels.

The exception was the Pelton Waterwheel Company of San Francisco, who are makers of impulse or tangential wheels that have been evolved from the necessities of use in the mountain districts of California, where pressure turbines were almost impossible. The plans submitted by this company were not commenced until nearly the end of the time allotted, were hastily made, and might now be greatly improved. They have been substantially adopted by M. Ferranti for the projected works on the Canadian side at Niagara.

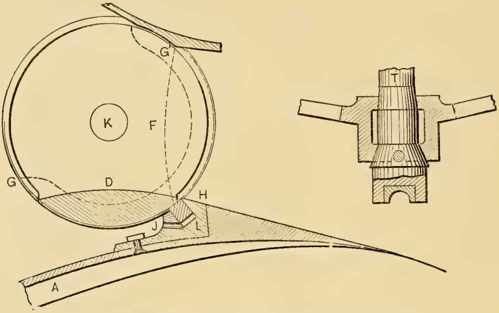

FIG. 5.—SECTION OF WHEEL GATE AND STEP, 1875.

Tangential wheels are quite simple in all respects but one, the form and position of the vanes or buckets. These have been tentatively developed on the Pacific Coast by the cut and try method, but there has besides been a good deal of mathematical treatment in the way of analyzing vanes in use, and perhaps no better example could be named of how powerless computation is to take the initiative and develop new things of the kind, unless supplemented by constructive skill and observations in practice.

In 1883 the University of California entered upon some experiments with tangential wheels, conducted mainly under the direction of Mr. Ross E. Browne in Professor Hesse's department of mechanical engineering. The bulletin published in that year by the College of Mechanics, except the fundamental principles laid down by Weisbach and others, has remained almost the only literature of these tangential wheels, and is now perhaps out of print.

Partial turbines, as they are called, were prepared in imitation of the Jonval and Fourneyron wheels, the vanes being carefully made to conform to the theoretical curves of these wheels. Why the Girard type, which is the true impulse wheel of Europe, was not included is known, but the result was that the highest efficiency was attained with the Pelton wheels, such as were then employed for great heads in the mines of California. Other tests made at the University of California were ot a laboratory nature, but conducted with great care, and no doubt indicate as nearly as possible the true efficiencies of the types of wheels represented. The results are shown in the diagram Fig. 6, which has been re-engraved from the original.

Tangential water-wheels, unlike pressure turbines, involve no intricate problems extending to all the parts involved. As before said, the whole problem of efficiency is narrowed down to the form of the buckets or vanes and some other

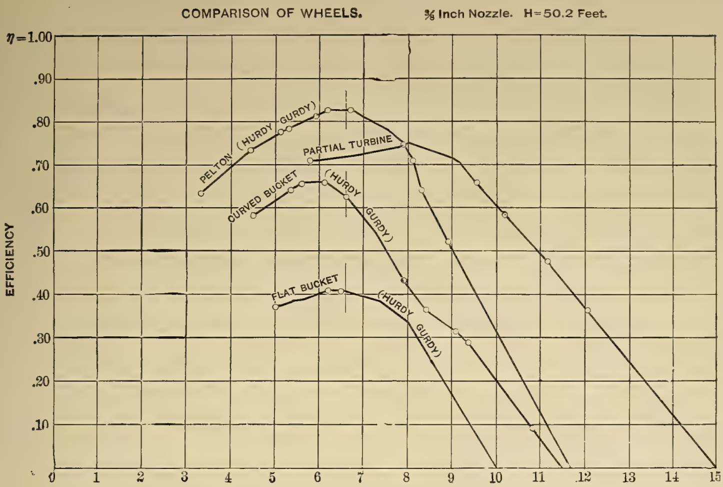

FIG. 6.—DIAGRAM OF WHEEL EFFICIENCIES.

conditions of minor importance, such as the form or section of the jet, which is commonly cylindrical because of that section presenting less frictional surface in proportion to volume.

Various forms of these buckets have been prepared and tried on the Pacific Coast, hundreds it might be said, and the results noted as carefully as possible at mills and flumes, by means of brakes and measurement of the water consumed.

These buckets, except the first crude forms, which were only flat planes or teeth like in a saw, have nearly all conformed to the principle of receiving the stream on a sharp apex that divides it, the sides terminating in curves that reverse its course. The object sought, or the ideal bucket, would be represented in the diagram, Fig. 7, in which the receiving or opposing surfaces will be a cylindrical dish-shaped vessel, terminating in a sharp cone, the surfaces or dimensions of the whole being as small as possible to avoid flowing friction.

The kind of bucket most extensively employed on the Pacific Coast is the Pelton form shown in Fig. 8, consisting of two shallow cups separated by an acute dividing wedge, the angles on all sides being divergent.

Fig. 9 shows the Dodd, or, as it is called, "sigmoidal" bucket, that has for two years past been applied with very good results.

Fig. 10 shows the Knight buckets, the invention of Mr. Samuel N. Knight of Sutter Creek, Cal., and extensively employed in mines and elsewhere with success. This form of bucket or the wheels of Mr. Knight, form quite a study in hydraulics. The stream applied is of an elongated or oval section in the plane of the wheel's rotation, and the chute or nozzle fits closely around the periphery of the buckets so that there is a question as to whether these wheels do not in some degree, perhaps in a considerable degree, act upon the principle of pressure or partial turbines.

Mr. Knight gains an important advantage over the plain jet wheels in the large amount of water which he can apply on the wheels with a single nozzle or chute, and thus can adapt his wheels to low falls. He has quite a large works at Sutter Creek, and extensive facilities for experimenting with hydraulic apparatus, and is, so far as the writer knows, the only successful maker of direct-acting hydraulic engines of large power for operating mine pumps.

In Europe, as before mentioned, the Girard or partial turbine wheel constitutes the only class operating by impulse or partially by impulse. These wheels, which in a less perfect form date from about 1855, are now constructed with much uniformity in nearly all the countries of Europe, where mill gearing is made, and the theory of their action is perfectly understood.

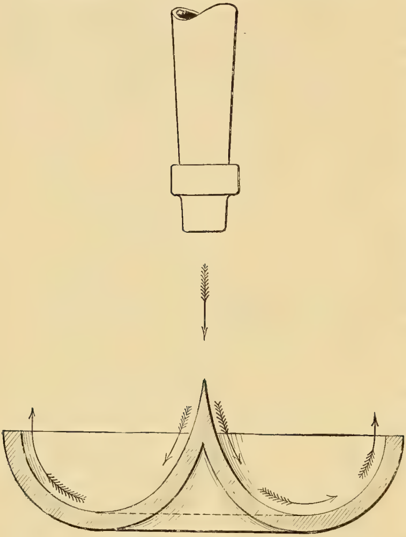

FIG. 7.—AN IDEAL BUCKET.

Fig. 11 shows the curves and form of vanes and chutes taken from the drawings of Messrs. Gunther & Co., Oldham, England. The right hand view is a vertical section, and the left hand view a radial cross section through a part of the wheel and the entrance chutes. These chutes *d d* are made in numbers sufficient to discharge the maximum amount of water required, and are uncovered by a circular sliding gate on top moved by a tooth pinion.

The part *a* contains the chutes, and *b* is the revolving portion or wheel, supported on a disc or set of spokes *c*. The wheels are flared at the bottom, as seen at *f*, to permit a more free escape of the water, and holes are provided at the sides for the escape of air, and to support the cores in casting the wheels.

Mechanically, and in respect to construction, these wheels are a refinement in hydraulic practice, and are made with great accuracy and completeness of design, due to emulation and a wide experience by many able firms. The name "partial turbine" is relevant and describes the Girard type of wheels, because they are really turbines having only a few instead of a completed set of chutes or inlets, with, however, the farther difference that the passages through the wheel are greater in area than the chutes, the same as in the Atkins wheel, before noticed. This permits an impinging action; the wheels being open or unfilled are not under pressure of the head, as in real turbines.

Reverting again to the buckets shown in Figs. 8 and 9, or indeed, to all buckets of this class that have been invented, it is obvious that when revolving on a wheel, the conditions under which they operate are different at all points of their passage through the stream. The angles and curves are constantly changing. If the surfaces of impingement are right at one point, they must be wrong at all other points while subjected to the stream. The resultant angles, with respect to the axis of the jet or stream, are continually changing, and the wonder is that the energy of the water thus applied should give out so high a degree of efficiency. On the other hand, if the water could be applied under uniform conditions as the buckets pass through the stream, there is no reason why an impulse wheel should not, as before remarked, give out ninety-five per cent or so of the energy imparted by the water.

It will, therefore, seem that a series of buckets rigidly attached to the rim of a wheel must of necessity change

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continually their position in relation to the stream as the wheel revolves, and that there is no possibility of uniform conditions during the period of the water's impingement, but this is not quite correct. A recent invention in these buckets really attains very nearly a uniformity of conditions, or of curves and angles during the whole of the working range of the buckets. It was an examination of this new form of buckets that led to the preparation of the present article, and the new features involved will now be explained.

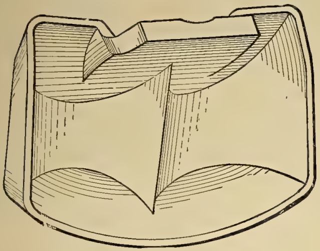


FIG. 8.—THE PELTON BUCKET.

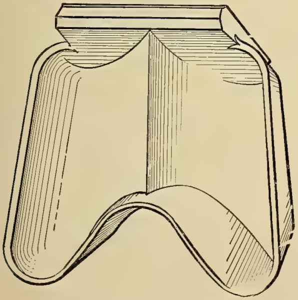


FIG. 9.—THE DODD BUCKET.

The invention referred to is that of S. Lucien Berry of Philadelphia, set forth in his patent No. 493,239, dated March 14, 1893.

The main figure of the drawings of this patent is reproduced on a smaller scale in Fig. 12, and is clear without much explanation. The line *y* of the stream or jet meets the buckets at *m m m*, radial or normal to their convex faces presented to the stream. In the preamble to the specifications of the above-named patent, it is stated that the invention "consists in forming the buckets with a double curved bottom, presenting a sharp dividing apex in the centre to split the stream or streams of water discharged on the wheel, and also curving the buckets in the opposite plane so they will present a convex surface, normal to the stream of water, in all positions of the buckets being acted upon.

"My invention also consists in forming the buckets open as to their outer ends, and reducing the edges thereof to a thin knife-like section, so there will be no disturbance of the stream discharged on the wheel by the buckets when entering it."

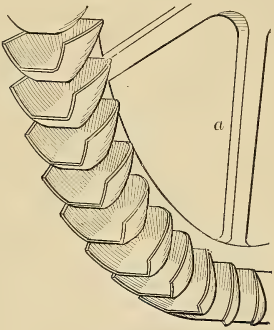


FIG. 10.—THE KNIGHT BUCKETS

The claims of the patent are as follows:

1. In a water-wheel driven by impinging jets, a series of buckets attached to the rim, double curved in their transverse section and also curved in the plane of rotation, as herein described, so as to present, in that plane, a convex face, normal to the impinging water, when the buckets are in the plane of the stream, in the manner substantially and for the purposes described.

2. In a water-wheel driven by an impinging jet, or jets of water, a series of buckets attached thereto, formed with a double curve in their transverse section curved also in the plane of rotation, to

present curved or convex faces normal to the impinging water in that plane, the outer ends of the buckets open in the form of a trough, in the manner and for the purposes substantially as described. 3. In a water-wheel driven by an impinging jet or jets, a series of buckets attached to its rim, the buckets having a double curve in their transverse section, and a backward curve in the plane of rotation, as herein described; the outer ends of the buckets open in the form of a trough, and the extreme end of the bottom and sides beveled to an edge so as to cut the jet transverse to its course, without disturbing the stream in entering, in the manner, substantially, and for the purposes described.

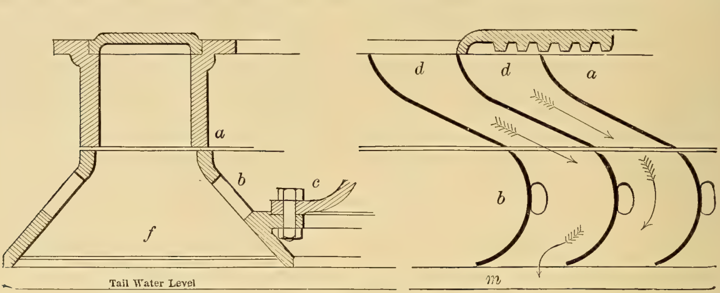


FIG. 11.—SOME ENGLISH VANES AND CHUTES.

Analyzed, these claims comprise "backward curved" buckets that present faces normal at all points to the line of the water's impingement; also buckets open at their outer end, that is, without obstruction to the resultant flow or reactive course of the water in a plane transverse to that of rotation, and also the entry of the buckets by sharp edges cutting transversely into the stream.

Here are three distinct features differing from former practice, and directed mainly to the attainment of uniform conditions throughout the working range of the buckets, and there seems only a single reason why this should not end the search after theoretical buckets, at least, with an amount of water or size of the jet that will permit an uniform action of the whole mass, and a reacting angle as nearly as possible in the plane of rotation.

The loss may be little or none when the wheels are operating under correct conditions. This, experiment alone can determine. No doubt there are many who would attempt at once a mathematical solution of the whole problem, and this would be simple enough if the buckets were fixed, but able hydraulic engineers, and we may mention among this number Ross E. Browne of San Francisco, admit that the phenomena attending on the operation of these wheels cannot be arrived at or predicted from computations.

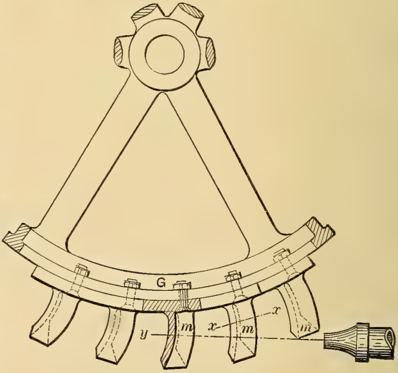
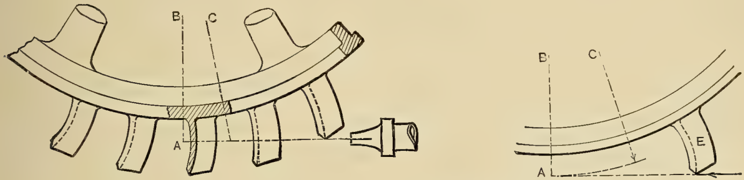


FIG. 1 .—THE BERRY BUCKET.

The writer has applied to Mr. Berry, the inventor of the buckets last described, for an analysis such as he could furnish of the action of the water on his form of buckets. The following is in substance the remarks received from him, together with diagrams to assist in explanation :

In that class of impulse water-wheels that may be called reactive tangential, that is, wheels that provide for a reversal of an impinging stream, the conditions that contribute to a high efficiency are : (1) A tangential application of the stream or jet ; (2) a short path for the water on the surface of the buckets ; (3) easy curves adapted to the change of course and velocity ; (4) entrance of the stream without disturbance or shock ; (5) a discharge of the water as nearly as possible reverse to its entering course, and tangential to the wheel ; (6) that these conditions should change as little as possible during the passage of the vanes or buckets through the stream. These conditions are as nearly as possible filled by the form of buckets shown in the following diagrams.



FIGS. 13 AND 14.—DIAGRAMS OF BERRY BUCKETS.

Complete tangential application of the water to wheels of this class is, except at one point, impossible. This is illustrated by the diagram Fig. 13, in which *A* is the line of the stream, *B* a radial line through the centre of the wheel at a right angle to *A*, and *C* a point at which the centre of a "severed section" of the stream will meet the bucket. The rotative effect of this water will be as the cosine of the angle formed by *A B C*. This is shown in a greater degree in Fig. 14, and may cause a good deal of loss if there are too many buckets. The frictional faces of the buckets should be as short and present as small an area as is possible, and smooth, two matters that have not always received the amount of attention they should in designing these wheels. The present form of the buckets permits them to be cheaply machined or finished by means of rotary milling tools, if the curves or faces are arcs of true circles, as seen in Fig. 10, which shows a transverse section and an outer end view of one of the buckets. The axis of the cutting tool would be at the centre from which the curves are generated, and the feed movement of either the work or the tools would follow the curved lines *E* in Fig. 9.

The angle *F* in Fig. 15 I make to depend upon the pitch or distance between the buckets as indicated, but this may not be important when a wheel is moving at a proper speed with relation to the water, or at $4\sqrt{H}$ in feet per second, which is considered a proper velocity. This should leave energy enough in the discharged water on the line *F* to project it clear of the next approaching bucket, as shown in Fig. 16. The theoretical loss by the divergence of the lines *F* from that of the stream does not amount to much, certainly not one per cent. at a proper speed of the wheels, there being no velocity to be considered when the wheels are running at normal speed.

Tangential discharge of the water from the buckets in the plane of rotation is another point that seems to have met with but little consideration in water-wheels of this kind. I had prepared diagrams to show the discharge in this plane with the present form of the buckets, but will not send them because the result is obvious so long as impingement of the water is against surfaces normal to the stream, the discharge being as nearly tangential as possible. With concave buckets, or those having closed ends, the discharge is at various angles and so erratic that at any speed wherein reaction is an element of work or propulsion, the loss is obvious.

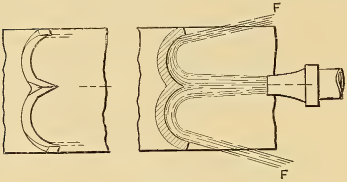


FIG. 15.

The determination of the actual as distinguished from the apparent angle of impingement, is another feature of some importance. Referring to Fig. 18, let *A A* represent the line of the stream or jet; *F* the point of the bucket's contact; *F G* tangent to the point *F*. Supposing the bucket to be moving at half the speed of the water, the direction and speed of the bucket at *F* is represented by *G F*, while *H F* represents the direction and speed of the stream; completing the triangle gives *H G* or *I F* as the direction of the stream in relation to a bucket at rest, and from *I F* must all diagrams relating to tangential discharge be determined.

In respect to non-disturbance of the stream, I assume that a thin edge entering it transversely is better than any entrance made at an angle as in Fig. 17, or any of the forms hitherto adopted, because not only must disturbance be taken into account, but also the effect produced by the diverted water while the stream is being severed. The two things must be considered together. The value or effect of disturbance is much more complex than the losses due to misdirected water, and while it may be difficult or impossible to arrive at conclusions inferentially, observation of a wheel's action will indicate at once any fault or loss from either of these causes.

This, and much more besides from Mr. Berry, not requiring quotation here, indicates that he has prosecuted his investigations in a very intelligent way.

Another feature of this new form of tangential buckets is that their form permits the jet or stream to be applied at varying distances from the centre of the wheel without any considerable change of the reactive or resultant angles of discharge, and consequently without impairing efficiency. This enables regulation of speed by adjusting the nozzles, which cannot be done with concave buckets without disturbance and change of the conditions under which a wheel operates.

The writer will not assume to determine farther than by inference what the result may be of this considerable change in the design and method of constructing tangential water-wheels, but will venture the opinion that in any case where the volume of water used is such that a jet or jets can be reduced to a small section, so that the whole stream will follow the reactive curves of the buckets, such wheels will give a higher percentage of useful effect than can be attained with any other type of water-wheels now known.

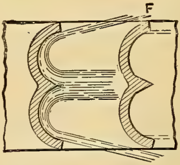


FIG. 16.

The Pelton Water-wheel Company of San Francisco, who control the patent on these new buckets for the Pacific side of the country, will soon conduct experiments to determine in actual practice what can be attained by the system, and will, no doubt, use such buckets in some experiments to be made by them under direction of the United States Navy Department for the transmission of hydraulic power on war vessels.

The commercial phase of this water-wheel problem while not a technical subject, must, in this practical country, be taken into account. It will not be pursued here farther than to say that compared to pressure turbines the tangential water-wheel plants in California do not cost per horse-power more than one-half as much as pressure turbines, and their maintenance not one-fourth as much. The speed or size of a tangential wheel can be varied at pleasure; so also its power, by simply changing the nozzles.

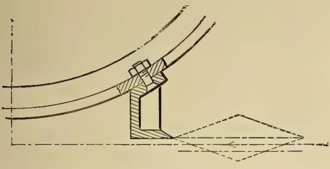


FIG. 17.

The wooden frames and other features of crude construction incident to an enforced cheapness and temporary or uncertain uses in mines, have done much to convey wrong impressions, and to divert attention from the true nature of the wheels and their merits, so it may be said that while the art or manufacture of such water-wheels has been going on for ten or fifteen years past under forms that gave a high efficiency, the fact has been hardly realized in a general way. The future promises a good deal more. A water-wheel without metallic contacts, without water-retaining joints, costing much less to construct, giving a higher efficiency and greater adaptation in the way of connecting than the turbine class, will not be long in finding its place in the engineering world.

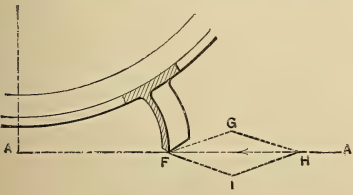


FIG. 18.

To these remarks on tangential water-wheels may be appended with advantage some generalizations or inferences respecting water motors. If one considers as an abstract problem the conversion of the weight of a descending body, mobile in nature, into rotative energy applied to a shaft or axis, the inference will be reached that no complexity or great variation in methods is probable.

If one will then refer to the literature of this branch of mechanics, for example, 365 pages of Weisbach, translation of 1880, devoted to water motors, and see the wonderful number of forms under which machines have been devised for this simple purpose; then examine page upon page of complex formulæ which endeavor to explain the phenomena of action in these machines, the conclusion must be that man's weak powers are incompetent to deal intelligently with the most simple of natural forces. There must also be the conclusion that mathematical treatment, however great its pretensions, can contribute but little to practical results, in fact, has not explained in a practical manner so as to command confidence, the forces that are set up in the action of turbine wheels, whether impulse, pressure, or reaction are principal, existent or non-existent.

If it is assumed that the best conditions of operation or the true theory of water-wheels, can be deduced from computation, we may ask why has not the best type in each class been established? Also, we may ask how can confidence be established in methods than can not explain and would condemn the American inward-flow or centre-vent turbine wheels which have given out the same useful effect attained by the refinements of the Fourneyron and Jonval types? And finally we may ask why the simple elements that enter into the form of buckets for tangential water-wheels have been provided for the use of those who construct and use such wheels? The fact is, that the scope and function of scientific treatment, in so far as water-wheels are concerned, amounts to an attempt to follow out and explain the forces supposed to be involved and acting. Certain premises are assumed, which if correct, lead to certain results, and no one can dispute that there is a distinct value in such deductions because they lead toward the true path and often save a great deal of wasted effort. To illustrate what we mean an example can be presented. Mr. Theodore Risdon, of Mount Holly, New Jersey, undertook, about thirty years ago, the improvement of centre-vent turbine wheels. He was not a mathematician in the sense of analyzing the action of water in such wheels, but proceeded from observation, making a great number of experiments, which ended in his reversing the curves of the receiving vanes in such wheels. There was no mathematics for this ; on the contrary, the receiving vanes or initial curves, as they may be called, had previously been laid down with great care and rested upon a supposed final law of hydraulics.

He reversed the initial curves, however, presenting a convex face to the entering water, and sent water-wheels to be tested to the Centennial Exhibition in 1876, that gave a better result than the most carefully designed Jonval wheels, and better than any other inward-flow turbine wheels, of which a score or more were tried. The Risdon inward-flow turbines stand at the present time, so far as the writer knows, with a record as high as any pressure turbine, even the accurately made Fourneyron wheels by Boydon and Francis. The efficiency for the Risdon turbines at the Holyoke flume in 1874 reached 91.30 per cent. with a full gate, and 72.77 per cent. with a half gate.

The writer is not arguing against scientific analysis and treatment of hydraulic subjects, but contends that it is high time that science should take the initiative and determine at least "something" in water-wheel practice that would stand as immutable rules in the future.

Of American inward-flow turbine wheels, not less than thirty different kinds are made at this time, and there is certainly no reason for this. There is only one correct form for such wheels, and the diversity of designs shows unmistakably that the perfect form is not known, and that there is a want of confidence in the data that exists respecting turbine action. The difference in the construction of such wheels is marked, while their relative efficiency does not vary more than thirty per cent., if so much.

THE LIFE AND INVENTIONS OF EDISON.*

By A. and W. K. L. Dickson

Fourteenth Paper.

EDISON'S Northern home Glenmont, in New Jersey, consists of an extensive and superbly appointed house, built in the most unexceptionable style, and surrounded by well kept grounds. Refreshingly independent of architectural rules, it yet presents a wealth of fancy, which brings into view at every turn unguessed and delicious surprises. It abounds in gabled roofs, picturesque nooks and angles, carved balconies and mellow sheets of stained glass, the whole set in a panorama of rare shrubs, floral arabesques and beds of emerald velvet, the brilliant coloring of which is thrown in broad relief by a background of sombre pines. A porte-cochère admits our vehicle and ourselves into a paved enclosure. Mounting the steps, we are admitted into the entrance hall, which, after the fashion of English manors, is luxuriously furnished, and serves as a general lounging place, rather than as a mere passage for ingress and egress. Red mahogany, cunningly wrought, enters into the composition of floor, walls and ceiling, affording an effective background for the glowing Eastern fabrics which abound. The furniture is upholstered in leather of a dusky crimson hue. An old time fireplace has its appropriate burden of logs and massive andirons, and is surmounted by a suit of knightly armor. A lordly staircase of polished mahogany faces the front entrance, on the first landing of which is an immense casement of stained glass, the jeweled colors of which float down to us in a species of glorified mist. On the right of this entrance hall is the library, containing many exquisite pieces of statuary, bronze and marble, together with a few choice paintings, among them an excellent copy of Guido Reni's "Aurora," Sauvage's "Meditation," and a life bust of Mr. Edison himself. Stained glass is also used in the room, and with considerable effect, sufficient light being admitted for purposes of study, without necessitating the garish glare attendant on the untempered daylight.

Re-entering the hall, we cast our eyes on the massive staircase which faces the front portal, and are aware of a most lovely vision, none other than the chatelaine of these fair domains. The jeweled tints from the great cathedral windows fall on her queenly head, crowned with its aureole of nut-brown hair; draperies of pearl and silver cling softly to her lissome shape, at her feet lie the royal webs from Indian and Persian looms, and about her cluster the masses of radiant bloom. Greetings exchanged, we mount a short flight of steps, facing the entrance, and pass into the dining room, rich with carvings of oak and mahogany, hunting and pastoral scenes, and heavy with the breath of flowers.

Back of this is Mr. Edison's den, than which no spot was ever less suggestive of its name. Nor does the task of "bearding the lion in his den, the Douglass in his lair," call for any special display of prowess. That animal, ensconced in the recesses of a deep arm-chair, and screened behind the pages of a New York periodical, turns on us a face so luminous with good nature and

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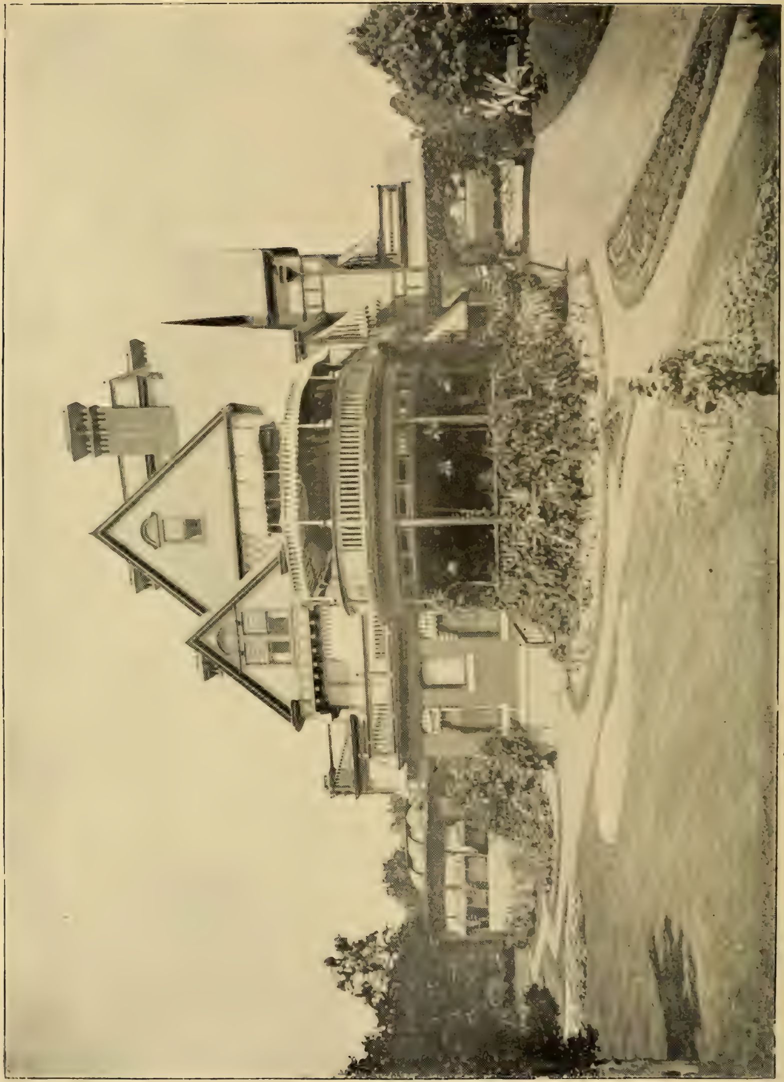
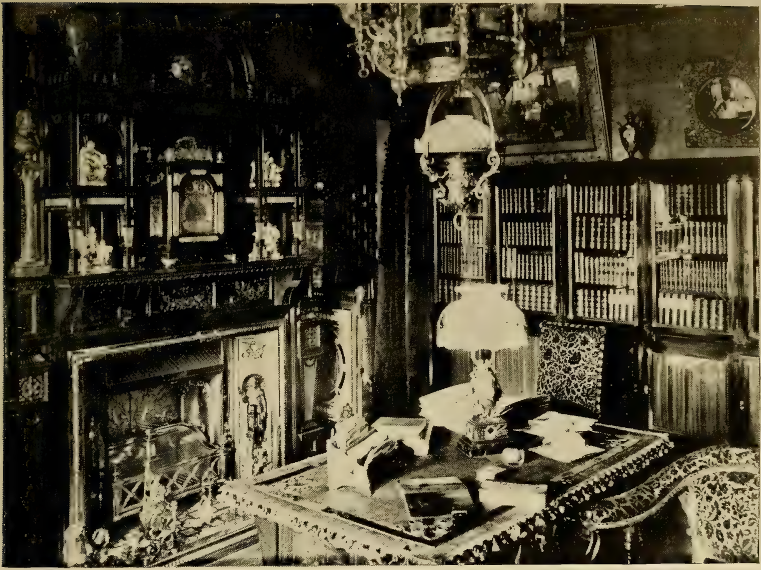
* Began in November issue, 1892.



GLENMONT, EDISON'S HOME.



THE LIBRARY.

kindly humor, as to have enlisted the affections of any, less familiar than we were, with his most lovable personality. We content ourselves with a warm grasp of both hands, in itself a vital tonic, for the inventor is a prey to one of his rare indispositions, and as he tells us, laughing, is "chockful of quinine." The drug has heightened his natural infirmity of deafness, and not until we aroused him, had he been aware of our presonce. It is pathetic beyond expression to see this man, to whom we owe such an immeasurable debt in the extension of our physical powers, patiently enduring the isolation which must be attendant on this dark and soundless prison, a stranger to all the sweet and interior harmonies which underlie the cadences of Nature's orchestral symphony.

The "den" is not what the title might suggest—a narrow cage, devoted to pessimistic soliloquies. It seems rather a general lounging place for the family, whose occupations are indicated in a variety of ways. Here is a Weber piano, full-toned and sweet; there is an organette or mechanical organ, a magic lantern with arrangements for exhibiting a superb collection of colored and uncolored views; a phonograph and several revolving bookcases, well filled with scientific books of reference, among which our vision naturally gravitated to a handsomely bound volume of CASSIER'S MAGAZINE. On the mantlepiece, which, like the other fittings of the room, is of white mahogany, are several ornaments, which possess a peculiar personal interest, in addition to their intrinsic value. Foremost among these are the statues of serpentine marble, gifts of the Russian Czar; the quaint Japanese vases, presented by the Society of Engineers of Japan; and the Krupp inkstand, a present from the bellicose manufacturer, and probably the most unique appliance of the kind. It consists of a collection of miniature guns and shells, made of Krupp steel, the ink wells being constructed of shells, while a heavy siege gun supports the penwiper, being elevated and depressed at will in the same manner as its martial prototype. Half a shell receives the pens, and the tall candlesticks which guard the outposts are made in the form of "Long Toms," the whole presenting a *tout ensemble* sufficiently realistic to find place in the War Department of Liliputia. It is significant to see this triumph of the pen over steel, and to note the docile way in which these grim servants of Ares lend themselves to the furtherance of the despised scrivener's craft.

In a bay window we ensconced ourselves with the hostess for the better contemplation of Mr. Edison's medals and decorations, which were effectually displayed on a background of black velvet. These comprise, among others, the Prince Albert gold medal, from the London Society of Arts (1892); the three degrees of the Legion of Honor —officer, chevalier and commander; the bronze medal of the Photographic Society of France, conferred in connection with the kinetograph; the Order

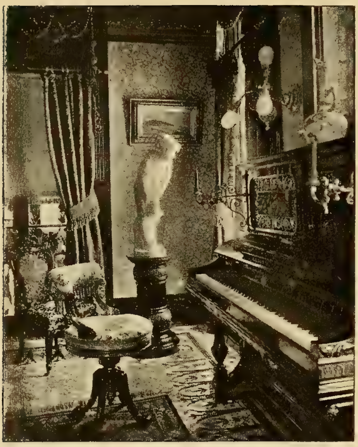
MADELINE.

EDISON'S DEN AT GLENMONT.

of Commander of the Crown of Italy; medals from the American Institutes of Boston and New York; from the expositions of Sydney (1879), Melbourne (1889), Milan (gold), Crystal Palace (1882, silver), and Paris (1879 and 1889). There is also a cigar case from the Czar of Russia, enameled in fervid blues, scarlets and gold, and embellished with an inscription, presumably of an affectionate and personal nature, but which, to the eye of the uninitiate, simply presented an aggregation of trip-hammers and other unintelligible signs. Having sufficiently examined these international tributes, we applied ourselves to the perusal of a very interesting scrapbook, compiled of autograph letters, relating to the trip undertaken by Mr. and Mrs. Edison to the Paris Exposition of 1889. Here was a letter from Madame Carnot, couched in pretty foreign English, placing the Presidential opera box at Monsieur and Madame Edison's disposal.

"We were totally unprepared for the reception which awaited us," said Mrs. Edison. "Three boxes had been thrown into one. The house was hung with American flags and national colors, and as we entered, the orchestra struck up the national anthem of America. Yes, it is impossible for me to feel anything but affection for the French. They were so enthusiastic, so kind and appreciative. I remember being especially touched on one occasion. Here, you see, is the programme of a Spanish concert, which we attended. As soon as it was over the audience left precipitately, and when we entered the brilliantly lighted Boulevard we found our carriage surrounded by a dense mass of people, shouting 'Vive Edison.'

"This invitation was given by Buffalo Bill, and signed, as you see, by some of the invited guests—Ada Rehan, Whitelaw Reid, Chauncey Depew and A. Anderson, the artist who painted



A CORNER IN THE DRAWING ROOM.

'After the Ball,' which surrmounts the staircase. This cross was affixed by Rocky Bear, the celebrated Indian chief, an impassive savage, who stared at me throughout the evening with a perfectly wooden expression and never volunteered a single syllable.

"We also visited Pasteur, who afforded us full facilities for examining his process of inoculation. In the Eiffel Tower we met, by special appointment, amongst other celebrities, the composer Gounod. The Figaro also gave us a dinner, and we took part in the civic banquet, at which were the assembled mayors of France, a platform of honor being reserved for Mr. Edison and his people. This message was phonographically received by Mr. Edison from the Queen of Italy immediatly upon his arrival in Europe: 'Women everywhere owe to Mr. Edison a deep debt of gratitude for giving them the means of bringing near to them the very voices of loved ones who are far away.'"

The mellow chiming of a distant clock reminds us of the passage of time and the extent to which we have trespassed on our hostess' leisure. We therefore emerge somewhat reluctantly from our downy nest and proceed to the examination of the reception rooms after a lingering glance at the den ceiling, which is painted by Tojetti, and set about with curious devices of glass, somewhat resembling the shining scales of the tarpon. The front reception room is garbed in no dominant tint or style, but abounds in artistic surprises. In this room, as in the entire house, stained glass is used, and exquisite are the effects produced by these molten gems. The drawing-room retains the same guise of fanciful grace as the reception room, and is in open rebellion to the imposition of stiff, archaic rules. Up stairs, the first room entered, is Mrs. Edison's private sitting room, fronting on the lawn and presenting a delicious medley of knicknacks, photographs, pictures, flowers and draperies.

"I love this room best of any in the house," said Mrs. Edison. "It seems to have more of that mysterious something which goes to make up the sum of home. There are my favorite poets;" she continued, indicating a handsomely bound set of volumes, "they are not complete yet, but I am gradually gathering them around me. These are portraits of Mr. Edison at different

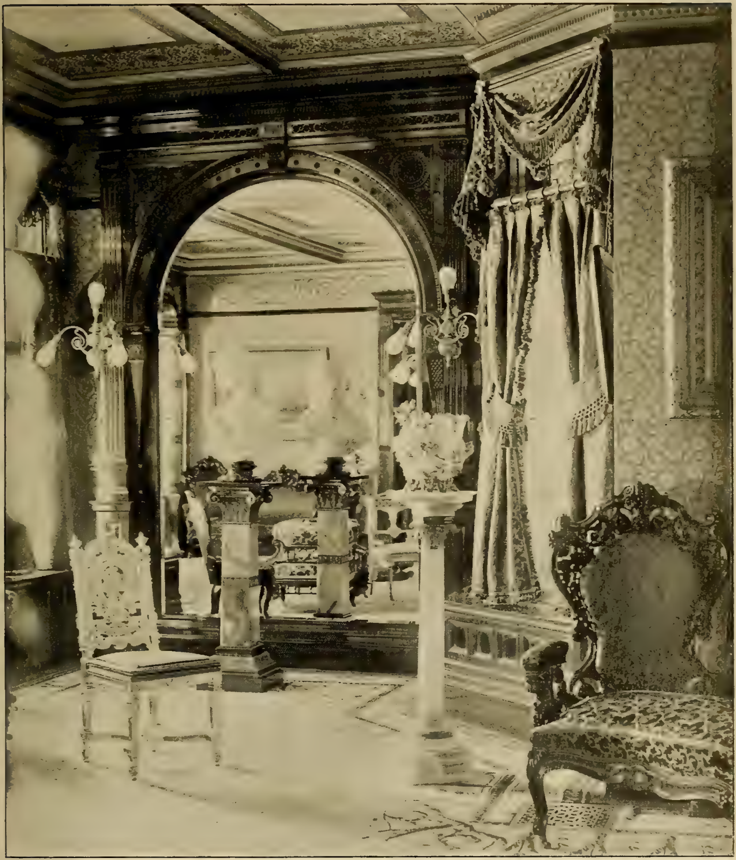
THE PARLOR BAY WINDOW.

COPYRIGHT PHOTO BY W. K. L. DICKSON.

Thomas A Edison.

NOVEMBER 5, 1893.

MRS. EDISON.



ANOTHER DRAWING ROOM VIEW.

times of his life; this is my father, and this is Mr. Edison's mother. But, of course, you are thoroughly familiar with all these. This, however, you have not seen,'' and she handed us a cabinet photograph of a middle-aged woman, with fine regular features, silver hair drawn plainly back over the ears and a peculiarly gentle and winning expression. ''This is my mother, my dear mother. This room is Marion's,'' she said. ''We fitted it up while she was away in Europe, but she has made many additions to it herself. The pictures, statuary and knicknacks are souvenirs of her trip. Yes, the coloring is soft and pretty, rose color and blue. Marion loves the French combinations and we tried to follow her tastes.''

We passed in succession through a number of exquisite rooms carpeted in rich-hued velvets. There were many

OFF FOR A DRIVE.

of these reception chambers, all fitted up in the same delicate hues, the ceilings painted with designs of flowers and cupids, after the joyous French fashion. The boudoir opening from the west bedroom seems like nothing in the world but a magnified bonbonnière in enamel and gold. Boudoir is a term derived from the French "bouder," to sulk, and these minute penetralia were originally provided for the indulgence of my lady's vapors ; but it is difficult to associate gloom with the rose-colored atmosphere of this elfin bower.

The topmost floor is devoted to the accommodation of the younger olive branches and their nurses, and is as cosy and liberal in its arrangements as heart of child could demand. The joint department, consecrated to Masters Tom and William, was surprisingly neat, and betrayed its occupancy only by a litter of paints and brushes. Mrs. Edison exhibited these artistic efforts with a pride scarcely compatible with the usual ogreish conception of stepmotherhood. "Tom has quite a talent in this line," she said, "at least so we all think, and he has a quick ear for music, which enables him to pick out tunes on the piano, and to ask me for any air which may have struck his fancy."

"You do not think he has inherited any of his father's genius ?" was asked, and on her reply in the negative, we inquired : "Upon which of the children, then, do you think the father's mantle will descend ?"

ENTRANCE TO LLEWELLYN PARK, EDISON'S HOME.

"Well," she replied, laughing slightly, "it seems rather early to pronounce, but still I believe Charles will be the one. Although he is only three years old, he has already shown an unmistakable liking for machines, steam cars, etc., and will stand for half an hour at a time, wrapped in contemplation, as if trying to get at their principles."

"Well," I said, "it will require an abnormal breadth of shoulders to wear Mr. Edison's mantle with effect, and the world will look with interest on his successor. There are still some secrets to be mastered, although your husband has successfully exploited innumerable fields of inquiry. He is, indeed, what Professor Young of the Smithsonian Institute termed him, the greatest genius of this or any other age."

"He is better than a genius," said the young wife quickly, while a softened look crept into her eyes, "he is a gentle, patient, kindly man. People know him exclusively as an inventor, but of his personal qualities they know little and care less. Discord does not live in his presence ; he has the happy faculty not only of possessing good humor in himself, but of promoting it in others. No matter what sort of a tangle the rest of us may be in, and how cross and out of sorts the household may be, it only needs for Mr. Edison to walk in for everything to get straightened out. I think," she concluded, with much emphasis, "that he is just lovely."

"No one could live with Mr. Edison in the close companionship of twelve years, and not recognize the justice of your verdict," was the comment on this wifely tribute, "and the writing of these papers has not been a dry compilation of facts, but a true labor of love."

Pausing for a glimpse at the billiard room, which is also located on this floor, we descend the stairs on our way out. As we emerge into the hall a patter of little feet greeted us, and two little elves, known in mortal land by the names of Madeline and Charles, fled into their mother's arms. Madeline had much to tell respecting the inclement conditions of the weather, and how the wind being cold, she had wrapped the dollie in furs and hood. Did I think "Charmante" would catch cold, she asked me anxiously, and I assured her with all proper gravity that she had probably averted that catastrophe by her timely precautions. Dear little mother heart ! Charles in the meantime had responded to the inquiry whether he could still turn a somersault, by a sudden and alarming inversion of his person, and a wild attempt

A LAKE IN LLEWELLYN PARK.

ONE OF THE DRIVEWAYS.

to balance himself on the top of his head, an acrobatic feat which he repeated several times, despite his mother's mild remonstrances, and the consequences to his attire. When he came up after one of these ineffectual attempts, flushed, tired, but totally undaunted, with his eyes sparkling and his lovely, childish face all aglow with fun and determination, it was easy to trace the mimic reflection of those characteristics which have furnished the basis of Edison's successful career.

Edison's purchase of Glenmont constituted a ten days' wonder to those acquainted with his rough and tumble ways and his utter disregard of luxury. That a nature, whose domestic requirements had hitherto been met by the most prosaic of surroundings, should suddenly develop a necessity for the very blossoming of æsthetic art, was indeed calculated to excite popular comment, but the inventor's selection was universally commended as a suitable shrine for his young and lovely wife. As a general rule, votaries of Hymen are launched into the gulf of matrimony with little protection against the jars and shocks which attend their descent, but in this instance, the celestial powers were kind enough to provide a stepping stone for the future Mrs. Edison in the shape of a parent endowed with decided mechanical abilities, the inventor of a mowing and reaping machine and other practical contributions to agriculture. To her early familiarity with the eccentricities of genius, and to the possession of a singularly placid and unruffled nature, is due the serenity with which the girl wife has applied herself to the solution of her marital problems. Not only has she displayed an admirable power of adaptation in regard to her husband's exacting career, but she has furnished another practical denial to the gruesome nursery code which converts every stepmother into a ravening ogress. A more harmonious family group it would be impossible to find The boys are not burdened with obtrusive piety, but their pranks are inspired by excess of animal spirits, rather than inherent malevolence. They expiate their sins by a sturdy devotion to their fair young stepmother, and by somewhat alarming attentions to the youngest scion of the house of Edison. Marion bids fair to emulate the strong, sweet nature of her mother. Her abilities have been well cultivated during an extended residence abroad, and she has acquired the ease and polish which travel and society impart without neutralizing her inherent honesty of disposition.

Our task is accomplished, rudely and imperfectly, but with such wisdom and conscientiousness as we have been able to command. A life so varied, and bearing so extensively on the inventive side of existence, has been felt to embody materials too voluminous for exhaustive treatment. It has been judged best to present the salient characteristics and achievements of the man, rather than a minute and wearisome collection of details. A semi-scientific biography, like the one in hand, is unable to meet individual requirements and must limit itself to the establishment of a general platform of ideas. Patent reports and technical books are accessible to specialists, desiring to make a minute study of separate inventions, and it has been thought wiser to convey the general substance of Edison's personal and scientific career rather than to confuse the ordinary intelligence with what, except to the initiate, might resolve itself into a mass of crude and undigested information, somewhat after the order of Dickens' graduate, whose scholastic equipment consisted of a multiplicity ot facts so tightly packed as to be totally inaccessible.

Possibly, at the close of a decade or two, if the great inventor and his chroniclers have not been removed to the higher schools of Wisdom, Edison's later achievements may be placed before the public. That he is on the threshold of vaster discoveries than have yet been given to the world is guaranteed by his early promise, his unquenched genius, and his splendid and untainted physique.

FALSE IDEALS OF THE BEAUTIFUL IN MACHINERY.

By W. Fletcher.

TO judge by the external appearance of much of the machinery that is turned out of modern engineering works in England, it would seem that very few draughtsmen have paid any attention to the subject of this article. While we are not entirely bereft of designers who can appreciate the beautiful in machinery, and who seek to embody external comeliness in their productions, the number of such persons is unfortunately very small—so small, indeed, that the influence of their work is scarcely felt.

There are draughtsmen who appreciate well-designed machinery when they see it, but have no notion of how to obtain a graceful appearance in their work, and if any meritorious outline should, perchance, leave their hands, it must be attributed to accident.

Some designers make an attempt at graceful curves and fail miserably, because they are unable to tell why one detail is beautiful and another unshapely. They never realize the refinement of outline secured by those having an educated taste, and the only course open to them is to carefully copy some good model. Tredgold appears to have understood the constituents of the beautiful in machinery, and in his work on the steam engine, published seventy years ago, says: "But at the same time that economy of power is considered, I think appropriate forms, good proportions and excellent workmanship should be attended to in all machinery, and in many instances it is desirable that they should be beautiful, for a beautiful machine will be so attended to as to produce economy, where an inferior one would perish by neglect." Another writer says: "In industrial machinery the amount of ornamentation employed is inverse as the amount of engineering skill employed in preparing designs. Ornament, when attempted, should never be carried further than graceful proportions; extraneous ornamentation, such as detached filigree work, or painting in colors, is so repulsive to the taste of the true engineer and mechanic that there is little use in arguing against it." Mr. John Richards some time ago wrote: "It is curious how for a long time in England, and to the present time in America, metal framing for machines followed the form of the wooden frames that preceded it. This similarity is in some cases traceable to the requirements of use, but generally it has not this excuse, and seems to

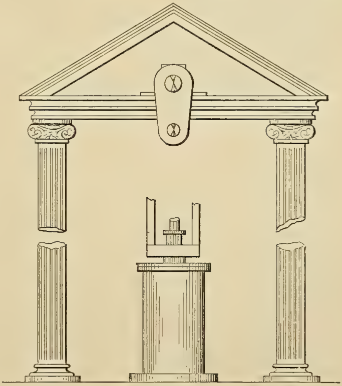


FIG. I.

arise from not considering the different natures of the two materials. Rib and plate framing is in most cases an imitation of wood framing ; so also are beads, moldings and panels with ornamentation of all kinds. These things are drawn from architecture and cabinet work, and have no legitimate place in connection with machine designs. The same remark applies to painting in colors ; however, in this there has been a great improvement of late years, the application of so-called ornamental painting being confined to field implements and household machines.''

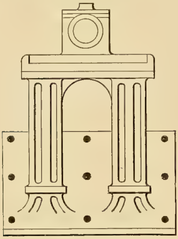


FIG. 2.

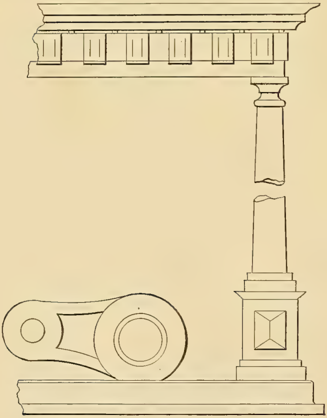


FIG. 3.

It should be distinctly understood that all architectural mimicry is utterly out of place when applied to machinery; indeed, many embellishments are actual disfigurements, and are used only by incompetent designers to make up for the lack of drawing-office experience. The beautiful in machinery can be appreciated by the eye, but it is not easily described. It is, however, brought about by an expenditure of drawing-office care in the arrangement of the parts so as to secure a symmetrical and simple appearance, perfect and graceful proportions and well curved outlines for giving uniformity of strength and stability. In addition, we should look for clean and sound castings combined with excellent workmanship. There are some engines which appear perfectly beautiful, and which by the mere external comeliness of their form, truth of workmanship and exquisite adaptation of parts to secure a given end, afford much mental enjoyment. ''How often do we see two or three of the principal details of an engine well worked out, but surrounded by a number of badly formed parts which mar the design as a whole. To produce beautiful machinery, it is necessary that the trifling details should be carefully considered, as well as the more imposing masses. It is just as easy to design a nice looking machine as an ugly one after the mind has been educated.''* The secret of the whole matter appears to be that no one can overreach his ideal ; if the ideal is not lofty the efforts cannot be of a high order.

A few examples drawn from practice show that false ideals of the beautiful in machinery are anything but extinct, and some of these objectionable things are sometimes called handsome. Only a few days ago a leading technical journal said, in reference to an engine on view at one of the shows : ''Messrs. ——— exhibited a vertical engine of old-fashioned design, not the less handsome for that, with its beautiful fluted columns and polished entablature.'' There would be reason for rejoicing, indeed, if fluted columns were found only on old-fashioned machinery. Not long ago the writer saw a vertical engine similar in design to the one just mentioned, and which was positively grotesque. Fig. 1 represents a sketch of this so-called ornamental engine. The cylinder is bolted to a foundation plate, and the crankshaft and bearings are supported by an elaborate entablature mounted on fluted columns with capitols. Fig. 2 shows a portable engine crankshaft-bracket architecturally treated. The beam engine has always been the subject of a good deal of ornamentation, consisting of architectural features and other examples of bad taste. English exhibitions have always been noted for some highly decorated engines of this type, and some makers even now rejoice in specifying their engines thus: "The cast-iron frame work of a compound beam engine comprises strong, angular, paneled pilasters and entablature on fluted columns." Fig. 3 shows a modern entablature of a beam engine.

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* Beauty of Design in Machinery, by W. Fletcher.

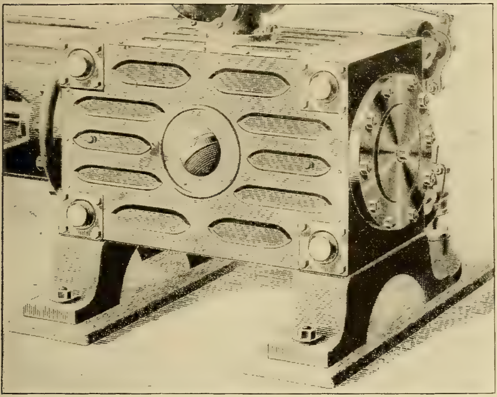


FIG. 4.

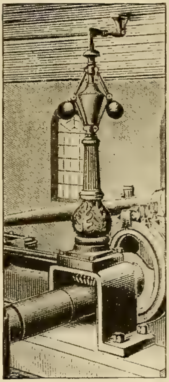


FIG. 5.

The next example which may be brought forward to show the false notions held by some engineers respecting beauty of design is the governor stand of a large mill engine illustrated in Fig 5. The governor, as here shown, is mounted above the crankshaft, so as to be driven by bevel gearing direct. The base of the stand shows no design whatever; it looks as though it was not made in iron, but in wood by a carpenter, and to make up for this unshapely base, the column is fluted and has a bead on the top with foliage near the bottom. It may have been copied from an old-time mahogany bedstead, looks exceedingly out of place on a steam engine, and is offensive to the last degree from an intelligent designer's point of view.

A few years ago American locomotives were embellished with objectionable ornamentation, but of late years this finery has been largely discarded. Even now, however, there are traces of it discernable. There is much to be admired in some of the American stationary engines. But why do so many firms work the cylinder lagging out in so curious a fashion as that shown in Fig. 4? It will be urged that there are many draughtsmen who have never fallen into the errors here named, and who have avoided architectural and cabinet-making features in their designs. It must likewise, however, be acknowledged that these men have never produced a beautiful design.

Ugly machinery may answer its end from a mechanical point of view, but ugly details are sure to be ribbed and angular, difficult to paint and equally difficult to keep clean, whereas the well designed parts are certain to have nicely rounded corners and an even exterior, easily painted and kept clean—advantages worth considering by themselves.

What designer of machinery ever thinks of expending as much thought on the shape of a detail of his creation as the artist does on some of the figures of his painting, or manifest such a desire as the sculptor does, that his work shall represent in every particular as near an approach to perfection as possible? Fixed engine frames, vertical engine standards and machine tools offer plenty of scope for the production of graceful shapes and dainty outlines—"forms," said the London Engineer some time ago, "which are beautiful to us in their graceful curves and in their mathematical accuracy, and we maintain that this sense of the beautiful, and the enjoyment which is derived from its possession, is as noble and exalted and as refined a feeling as that experienced when we examine for the first time a lovely Greek urn just unearthed from classic ground."

ELECTRIC RAILROAD POWER UNITS.

By E. G. Connette.

ONE of several committee reports submitted at a recent meeting of the American Street Railway Association was devoted to power house engines for electric street railroads in which naturally the question of sub-division of the total power in any particular case came up for consideration.

When electricity was first introduced as a motive power for street railway transportation the largest type of generators were small units as compared with those manufactured at the present time, and, as a rule, high speed engines of from one hundred to two hundred horse-power, belted direct to the generator, were in most cases adopted without regard to the size of the plant. In some instances Corliss engines were installed and the dynamos connected to the countershaft. In nearly every installation mistakes of more or less proportion were made, not due, however, to the fault of street railway people, but to the lack of knowledge on the part of the manufacturer as to what was actually necessary to properly fulfill the requirements of the new field of traction. The pioneers of electric traction have, as a rule, suffered from these mistakes by the expense of changing to modern, improved, and more economical machinery, or have been financially compelled to jog along with their obsolete outfit and consequent large power house expense. Local surroundings and conditions will, to some extent, govern the division of power into units, but generally the following principle will be safe to follow: The size of the proper unit of subdivision should be such as to give the required relay or reserve above the maximum power adopted. This will apply equally to boilers, engines and dynamos. The following table will serve to show approximately the proper proportion:

Maximum H. P. Required to Operate Road.	Number of Engines Required.	H. P. of each Engine.
200	2	200
400	3	200
600	3	300
1000	3	500
1500	4	500
2000	4	750

It will be observed from this that enough engines are provided to furnish the maximum horse-power required to operate a road and have a surplus of one engine. This is very essential, as it enables the engineer to keep his engines in perfect adjustment and repair, having at all times an extra engine to work on, or, in case of a breakdown, the extra engine is ready to take the place of the disabled one. The "maximum horse-power required to operate the road," referred to in the table, is not to be taken as the sum of the powers needed by each car in service, except in case of small installations, since the maximum power required does not increase in proportion to the number of cars in use, the line losses not being materially increased with increased traffic, and because as the number of cars increases, the fluctuations of load tend to balance themselves and to reduce the maximum load nearer to the average load. Thus in a ten-car plant, cases will occasionally occur when all of the cars will require their full power at the same time, and the power plant must be planned accordingly, but there is no probability that all of the cars of a one hundred car plant will all require their full power at the same time; from sixty to seventy-five per cent. of this power, depending upon local conditions, will be sufficient for this plant.

Letters to the Editor.

NATURAL GAS IN CHINA.

Reading, a few months since, the paper in these pages on natural gas and oil production in the United States brought to mind an interesting account of some natural gas wells in China, sent to the State Department at Washington several years ago by the United States consul at Peking. Some of the facts there presented are worth repeating even at this later date and are strikingly suggestive of the enterprise of the supposedly unprogressive Chinaman.

The gas wells in question are located near the town of Tsi-lin-tsing, in the vicinity of which large numbers of salt wells are found, which latter, in fact, appear to have really been responsible for the exploitation of the former. To make a well the Chinese use a long and elastic bamboo pole, supported in the middle by a cross piece, a rope made by coupling the ends of long slices ot bamboo, and an iron instrument which weighs about 160 pounds. The rope is fastened on the thin end of the pole, and the iron on the end of the rope. A slight up and down motion of the thick end of the pole makes the iron jump and bore a hole with its broad, sharpened edge. The ground to be perforated consists chiefly ot sandstone and clay. When a portion of the rock is disintegrated, clear water is poured into the hole, a long bamboo tube with a valve in the bottom is lowered, and the turbid water is raised to the top. Pipes of cypress wood are rammed in to protect the sides of the bored hole and to prevent the water contained in the surrounding ground from getting access to the well. The pipes are attached to each other at the ends with nails, hemp and tung oil. The inner width of the pipes is about five inches. As the work proceeds, the pipes are rammed deeper, and a new one is attached on the top; the rope, too, is made longer. At a depth varying from 700 to 1000 feet the brine is struck, and the well is fit for use. The brine is raised to the top through long bamboo tubes and bamboo ropes by means of a horse-whim, and is then carried to large pans for evaporation, or led to them through bamboo pipes. Beside these wells there are others, which are bored to a depth of from 1800 to 2000 feet. At that distance below the surface petroleum is struck. Immediately on reaching it an inflammatory gas escapes with great violence.

Work is then stopped, and a wooden cap fastened over the mouth of the pit, perforated by several rows of round holes. In each of them a bamboo pipe is inserted, and through these the gas is lead under the evaporation pans. The pipes ramify, and on each end a tapering mouthpiece, terminating in a small aperture, is attached. The gas is then used for evaporating the brine.

The enterprising spirit which induced the Chinese to examine the ground at so great a depth is said to have had its origin in the drying up of a brine pit. The proprietor was in hopes of meeting brine at a greater depth, but found, instead, the gas. When the country was infested with rebels during the Taiping rebellion they removed the cap from one of the gas pits and set fire to it. Since that time, or at least up to the time that the original account was written, a long column of fire rose from that pit.

The gas pits and brine pits are owned separately by corporations. The owners are subjected to the control of the Government. The Government monopoly is in the hands of the "Taotai," who resides at that place. The salt works of Tsi-lin-tsing yield considerable revenue to the Government, and have, besides, enriched numerous proprietors, and given occupation to a numerous population. Of "fire pits" there are twenty-four, and the salt pits are innumerable. W. H. FIELDING.

AIR BRAKE PUMP PERFORMANCES.

ATTENTION was recently drawn to a circular issued by the Westinghouse Air Brake Company, called "A comparative test of the Westinghouse Air Brake Company's nine and one-half inch Air Pump and the New York Air Brake Company's No. 2 Duplex Air Pump." It is so at variance with actual results universally obtained with our Duplex Pump, that we repeated the tests under the same conditions, measuring the air with three reservoirs in the same way. The results of the tests were as follows :

NAME OF PUMP AND SIZE.	DUTY required to raise the pressure from atmospheric pressure to 85 pounds per square inch in one cubic foot of space, pumps working against a constant pressure of 90 pounds per square inch in main reservoir; steam pressure 140 pounds per square inch.		Piston Travel in Feet, per Minute.
	Time per Cubic Foot of Air.	Steam per Cubic Foot of Air.	
The New York Air Brake Company's No. 2 duplex pump. Two steam cylinders 7 in. diameter, and two air cylinders, 10 in. and 7 in. diameter.	$7\frac{174}{1000}$ seconds.	$1\frac{881}{1000}$ lbs.	174 ft.
The Westinghouse Air Brake Company's 9½ in. air pump. One steam and one air cylinder, each 9½ in. diameter....	$9\frac{799}{1000}$ seconds.	$2\frac{744}{1000}$ lbs.	108.3 ft.

The test proves that the New York duplex pump delivers thirty-four per cent. more air per minute than the Westinghouse nine and one-half inch pump. It also shows that the New York duplex pump delivers forty-six per cent. more air with the same amount of steam. This is in accordance with the results which should be expected from the principle of construction of the duplex pump. The capacity of the two air cylinders is fifty per cent. greater than the capacity of the two steam cylinders. Both air cylinders are filled with free air every stroke, and this is delivered to the reservoir. The efficiency must therefore be fifty per cent. greater than is possible with the Westinghouse pump, as that can only receive one measure of air for one measure of steam. If any different results have been secured with the New York duplex pump it is because the pump was out of order.

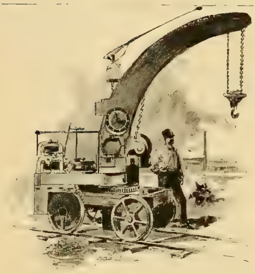
The amount of heat developed in compressing air is in proportion to the rapidity of compression. A higher temperature might therefore be expected from a pump that compresses thirty-four per cent. more air in a given time. Our duplex pump was designed for a special purpose, namely, to furnish air for operating air brakes. In this service it is utterly impossible to generate sufficient heat to impair the efficiency of the pump.

THE NEW YORK AIR BRAKE CO.

Current Topics.

It is interesting to note that English enterprise is just now being devoted to the equipment of two lifeboats with water jet propellers, a well-known firm being engaged in the building of the vessels, one of which is intended for the Royal National Lifeboat Institution, and the other for the Lifeboat Institution of South Holland. It is not clear why this system of propulsion should have so well commended itself as to prompt this venture. All past experience with it, and of which anything definite is known, has been discouraging, as remarked in these pages last month, and the performance of these new boats will, therefore, be all the more noteworthy. As currently described, they will be practically similar to ships propelled with twin screws, with a separate engine for each screw. Each boat will have two water inlets and two centrifugal pumps, and the latter will be so arranged that they can be run independently of each other if necessary. There will also be side discharge pipes, so that when the boat is on the weather side of a wreck, and likely to be driven up against it by the force of the wind and the sea, the water can be discharged from the pipe nearest the wreck and made to act not only as a buffer, but also to propel the boat away sideways. About 200 horsepower is to be provided for each of the boats. With their completion and test we may perhaps learn something about hydraulic propulsion that may have hitherto escaped the attention of most engineers.

AN electric traveling jib crane, which has just been built by the Oerlikon Machine Works in Switzerland for the St. Chamond Steel Company, is, in several respects, an interesting outcome of recent progress in electric power applications. So far as we are aware, nothing just like it has yet been turned out elsewhere in Europe or in the United States, though this may be possibly accounted for by the fact, as put by an electrical engineer, that there has been no special demand for a crane operated after this fashion. The particularly interesting features of the outfit are found in the manner in which the current is conveyed to the motors with which the crane is equipped. There is an overhead trolley wire, just as in the case of an electric street railroad, strung at a sufficient elevation to clear the highest point of the jib, so that the latter may be swung around in any direction without meeting any obstruction, and the jib itself carries the familiar trolley pole, the whole arrangement being modeled after current street railroad practice. Power from the armature shafts for hoisting loads and for propelling the crane carriage is transmitted by worm and bevel gearing. There are, altogether, two motors, the hoisting motor serving not only its own special purpose, but also for turning the jib, which latter requires very little power, resting, as it does, on ball bearings. The jib turning mechanism can be quickly thrown in or out of gear by a small disengaging gear. The base of the trolley arm admits of three independent, relative movements, giving the whole outfit the flexibility imposed by the working requirements. The crane weighs, in all, 15,000 kilogrammes, or about sixteen and one-half tons, and its maximum lifting capacity is eight tons at a speed of about four and one-half feet per minute, while lighter loads can be raised at speeds as high as nine feet per minute. At a voltage of 105 the current consumption for an eight-ton load amounts to sixty-seven ampères, while the current for propelling the crane with this load, at a speed of about sixty-five and one-half feet per minute, figures up twenty ampères.

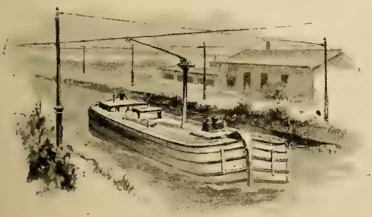


ELECTRIC TRAVELING JIB CRANE.

KEROSENE as a disincrustant for steam boilers has become pretty well known in the United States, and many applications have been made of it as such with very satisfactory results. Numerous instances are on record where quite formidable deposits of scale have yielded to its influence in a short time, and have flaked off or become so soft that their removal was easily accomplished without the usual uncomfortable application of hammer and scaling chisel in cramped quarters. More recently European engineers, too, have begun to appreciate the efficiency of the oil treatment, and on some of the German railroads it is now extensively used both for locomotive and stationary boilers. Generally, the oil is there used after the boilers have been washed out and dried, being applied with brushes, but it is also sometimes pumped in with the feed water and allowed to spread over the internal surfaces by slowly draining off the water through the blow-off cock. In all instances, those who have tried it are understood to have become thoroughly satisfied of its merits.

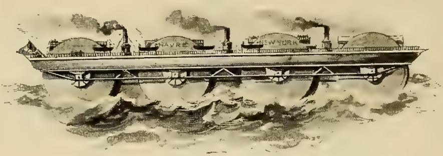
A RATHER interesting item comes from France relative to the extension in height of a factory chimney at Nancy without interrupting the work of the establishment to which it belonged. The chimney measured about 100 feet, but repeated additions to the boiler plant had made it too small for its work and it became evident that either a new one would have to be built or the height of the old one would have to be increased. After some deliberation, the owners accepted the offer of a German contractor—Augustus Bartling, of Bernburg—to build an addition to the old stack without interfering with the regular work of the establishment, and from all accounts the operation seems to have been carried out to the satisfaction of all concerned. Mr. Bartling fixed a series of light steel ladders to the chimney by means of iron hooks driven in between the courses of brick, erected a pulley at the top of the chimney and a flight of scaffolding all round, and then, having lowered the cornice surmounting the chimney, built on to the top at the rate of about four feet per day. Thirty feet were added in this way and the whole work was completed in a little over a week.

THE electric trolley system on canals, for canal boat propulsion, has for several months past furnished material for speculative newspaper comment. It seems to be now definitely settled, however, that the experiment is to be actually made, at least in the State of New York, and preliminary arrangements have been carried out for the institution of early tests on the Erie canal near Rochester. Wires are to be suspended over the canal by poles on each side, just as they are held in the streets and something akin to the regular street car trolley will carry the current down to the motors in the boats. The contemplated trial is to be made partly in the interests of the Niagara Falls Light and Power Company, which would naturally find a valuable and substantial customer in the Erie canal in case electricity should there commend itself for motive power. At present there seems to be no reason why it should not, unless the cost of canal boat traction by the traditional mule should be so low as to far outweigh everything else of importance; but the experiment will be watched with interest everywhere.



AN ELECTRIC CANAL BOAT.

IN these days of revolutionary projects in matters mechanical and scientific, unusual engineering exploits have lost much of their tendency to create surprise. Still that sensation may be produced in a mild degree by the latest scheme of ocean transportation which has reached us from France and which has M. Bazin, not unknown in engineering circles, for its author. M. Bazin proposes, in brief, to build an Atlantic liner on eight rollers with the view of securing speed much higher than any thus far attained, arguing that the wheels or rollers on which the vessel is to rest will so greatly diminish the resistance offered by the waves that thirty knots an hour will be easily within the bounds of possibility and will enable the passage from Southampton or Liverpool to New York to be made in four days. The rollers are to enter the water to a depth of about twenty-six feet and revolve within a platform placed about twenty-four feet above the water, so that there will be a rolling instead of a gliding body as is the case in ordinary ships. The rollers presumably are to be worked by engines to secure propulsion. M. Bazin claims to have settled by experiment that the stability of the roller type of vessel is at least as great as that of the ordinary type, and believes that the construction of his design of ship will be much less costly than



FROM LIVERPOOL TO NEW YORK IN FOUR DAYS.

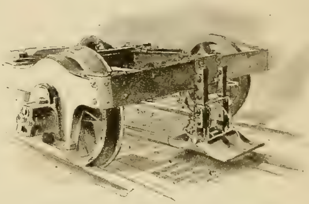
that of the usual description. According to French report, it is proposed to put M. Bazin's plans to a practical test by constructing a vessel about 400 feet long and of about ninety-foot beam, with rollers seventy-five feet in diameter and thirty-five feet wide. The latter are to make twenty-two revolutions per minute.

ENGINEERING enterprise in China, particularly in so far as it concerns railroad building, has had, and is in fact still having, a good deal to contend with in the way of native prejudice, cupidity and superstition, and the tales are many that have been told of the peculiar difficulties encountered in that country by European engineers and engineering syndicates in the course of their operations. When, for example, the first railroad was built, a number of years ago, the necessary land, it was stated, was bought from several hundred different proprietors, all of whom wanted additional bounties for the disturbance of ancestral graves, which, as may be known, abound in what the "foreign devil" would be apt to consider rather unusual localities. One proprietor claimed to have buried on his strip of land no less than five mothers-in-law, for whom he had to be paid. Satisfying him naturally resulted in a marvelous multiplication of dead mothers-in-law, who thus soon became the chief item in the cost of the land. Another curious example of the difficulties of railroad construction in the Celestial Empire has more recently been mentioned, and has been afforded by the conduct of the Tartar general of Moukden, the capital of Manchuria, in connection with the surveying work of the railroad from Kirin, another large Manchurian town, to Newchwang, the seaport of the province. According to current report, it was proposed to make a junction on this line for Moukden at a place a short distance outside the city; but the general got a number of geomancers to investigate the effect of this selection upon Moukden. These sages reported that the vertebræ of the dragon which encircles the holy city of Moukden would be broken by driving the long spikes of the railroad ties into them, and accordingly the general vetoed the decision of the engineers and directed them to carry the railroad in a straight line from Kirin to Newchwang without approaching Moukden at all. This, while a shorter route, would compel the crossing of a low and marshy tract of land, liable to floods, and only sparsely populated.

FOR several years past vertical forms of steam boiler have been "boomed." Various modifications of the ordinary upright design have been proposed and introduced, and each one has had claimed for it some peculiar virtue of its own, while collectively they have been warmly advocated by some as desirable substitutes, in most cases, for all other types of stationary steam generators. The first cost of the vertical boiler, it is generally claimed, is moderate; no special setting is necessary; repairs are easily made, and compactness and, on the whole, efficiency are secured by its use. This is a fair string of arguments, apt to strike one, at first thought, in a convincing way. Looking them over a second time, however, the suggestion presents itself that, after all, some of the other boilers in common use—the ever popular return tubular, for example—afford practically the same advantages, and, besides, are free from some of the drawbacks inseparable from the vertical design.

IN the matter of freedom from danger from low water, cheapness as regards setting and small floor space necessary, the vertical boiler finds undoubtedly its strongest support, and its advantages in these respects are fully admitted and well recognized. It may also be held with some reason that the steam which it furnishes is slightly superheated and consequently dry, the upper ends of the tubes acting as superheating surface. Beyond this, however, generally speaking, the comparison with other types becomes less favorable. In point of evaporative power the vertical boiler is certainly not remarkable—in fact, generally below the average, and in comparing the performances of ordinary horizontal brick-set boilers and of uprights, the relative capacities have always been found to show a heavy balance in favor of the former. As to freedom from danger in upright boilers, this, as in many other forms, with the exception of the low water danger to which reference has already been made, is maintained only by judicious management; and finally, as regards durability and lightness of repairs, experience shows that these items cannot be advanced as favoring the type. As a matter of fact, some of the latest modifications of the vertical boiler have in these respects proved sadly disappointing to most of their users, and have become looked upon as chronic sufferers from some of the ills that boilers are heir to, notably leakage, one of the most annoying of all. Those, therefore, who for some occult reason think that they must have a vertical boiler, would do well to keep some of these points in mind. They bear directly upon what most interests the steam user—the quantity of water evaporated for a certain expenditure of money.

One of the several features of interest of the electric elevated railroad which was put in operation at Liverpool, England, during the present year is found in the method which has been adopted of conveying the current from the transmitting line to the car motors. The road is carried for the greater part of its length on an iron viaduct, much after the manner followed in connection with the elevated railroads at New York, Chicago and several other cities. Instead of being supplied through an aerial transmitting wire, however, carried on poles as in the case of the familiar trolley street car lines, the electric current in this instance is led through a conductor rail laid between the tracks on the regular roadbed and resting on insulators. The trolley arm and wheel, on the other hand, are supplanted by a current-collecting brush, extending downward from each car and sliding along the conductor rail which latter is of an inverted trough-shape and is made of a special quality of steel of high electric conductivity. At the several switches, at stations and some other points along the line, the continuity of the conductor rail, naturally, must be broken, and in order to overcome any difficulties of transmission which might result from this, the rail is made sufficiently high to bring its upper surface about an inch above the plane of the regular track rails, and the collecting brush or shoe is made of such length that it easily bridges over the gap between the ends of the rail without itself coming in contact with the track rails. A very good idea of the brush arrangement will be given by the small accompanying illustration. To a certain extent it recalls the plan followed ten or eleven years ago in connection with the Daft electric locomotive experiments made on one of the New York elevated railroads, in which a central rail served similarly as a current conductor. At present, however, the Liverpool line is the only one on which this system of current transmission from power house to car motor is in use. The much spoken of Buda-Pest line in Hungary, of course, also dispenses with aerial wires strung on poles, but there the conductor is run in an underground conduit between the tracks and the whole arrangement is essentially different from the one just described.

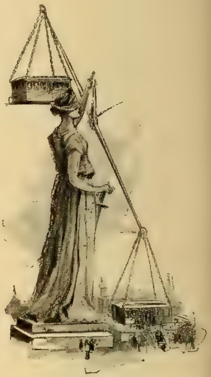


A LIVERPOOL ELECTRIC RAILROAD DETAIL.

The disposition to be made of the World's Fair buildings at Chicago and of some of their accessories has naturally excited a good deal of interest, much of which has been centered in the great Ferris wheel. People in all parts of the world want to buy it. One company wants to take it to Coney Island, near New York; another, to London, and still another, to Paris. Propositions of all sorts are said to have poured in daily on the company controlling it, but its fate is yet unsettled. While the big wheel, therefore, is no longer a novelty, and has, in fact, become known to almost countless multitudes, both through newspaper accounts and through personal inspection, brief reference to it will well bear repetition. The wheel may be said to be of the bicycle pattern, measuring 250 feet in diameter and twenty-eight feet in width, while the two outer bands are forty feet apart. The total height of the structure is 264 feet. The towers that support the wheel are pyramidal in form, 135 feet high to the centre of the shaft, with a base forty by fifty feet. The tops of the towers are six feet square and support the bearings. The shaft is of forged steel forty-five feet long, thirty-two inches in diameter and weighs, with the hubs, sixty tons. There are thirty-six cars, twenty-six feet long, thirteen feet wide over all and seven feet high in the clear inside, which will seat thirty-eight persons each. They are suspended from the periphery of the double-wheel by heavy steel pins in the top of the car so that the weight of the car always keeps its floor very nearly level. Power for turning the wheel was furnished by a pair of thirty-six by forty-eight inch engines, rated at 1000 horse-power.

THE FERRIS WHEEL.

THAT so unique a structure should have received an immense amount of advertising is easily understood and it is equally evident that to turn out anything which will favorably compare with it in its way on any other similar occasion will call for no ordinary degree of ingenuity and enterprise. Much thought, indeed, has already been spent on the question of providing sensational attractions for some of the future expositions which have been planned and while in the case of the Paris Fair, to be held in 1900, nothing has yet been proposed that seems certain of execution, the forthcoming Midwinter fair of San Francisco will probably have a novelty of striking character. It is to be nothing less than a colossal statue of Justice, somewhere in the neighborhood of 150 feet high, supporting the usual scales, but of immense size. The scale-pans are to be represented by cars, capable of holding each about fifty people, and the scale beam will be a truss about 300 feet long, oscillating like a walking beam on a ferry-boat, and lifting the cars to a height of nearly 300 feet above the ground. Comparatively, and in point of size, therefore, something so dear to the American heart, the Ferris wheel will be stripped of its glory.



A PROPOSED SAN FRANCISCO FAIR ATTRACTION.

BOSTON'S municipal authorities recently took up the work of guarding the city against a threatened smoke nuisance by issuing a notice to users of bituminous coal calling attention to a late enactment of a State law against the emission of smoke into the atmosphere, and ordering them either to take suitable measures to repress their production of smoke within reasonable limits, or to discontinue the use of bituminous coal altogether. It remains, of course, to be seen what "reasonable limits" of smoke production may be interpreted to mean, but there can be no question that the best measure for diminishing the nuisance has been taken by giving the order that the emission of smoke must simply stop or be curtailed. To what extent smoke production may be effected by abandoning soft coal as a fuel was very strikingly shown a few years ago in one of the suburbs of Cincinnati. That city suffered—in fact suffers still—almost, if not quite as much as any place in the United States, from the smoke of soft coal which forms the ordinary fuel of the city. Many of the occupants of the fine residences in the suburbs, however, refrained from the use of bituminous coal as much for the sake of their neighbors' comfort as their own. They kept the atmosphere clear about them by burning only anthracite coal, coke or wood. There was no general understanding on the subject, but each person acted upon his own sense of courtesy and cleanliness. The result was almost perfect freedom from the smoke nuisance, and afforded an example that might be imitated to advantage by many others.

In the improvement which has been made during the past twenty years in the design and construction of gas engines, comparatively little attention has been given to the matter of utilizing the waste heat of the exhaust gases, notwithstanding the fact that development in this direction would seem to promise an appreciably increased economy of fuel. Besides the waste entailed by the escape of these gases, which are at relatively very high temperatures, there are two other important sources of loss in engines of this type,—radiation and absorption of heat by the water jackets,—but these may, at present, be regarded as unavoidable. Engines have been proposed which dispense with water jackets altogether, and some of them have been built and are in current use—the Bisschoff engine, for example, in which the cylinder is cast with a number of external radiating ribs or fins which carry off the heat. There seems to be little probability, however, of such motors coming into extended practical use. It is significant also that the most successful gas engine builders appear to regard the method of external refrigeration as a necessary evil and make no serious attempt to do away with it. Putting aside, then, the losses due to radiation and conduction, amounting in all to about sixty-six per cent, we have about seventeen per cent of the total heat of combustion converted into available power, while an almost equal quantity of heat passes away with the exhaust gases without performing any duty. In gas engines of good construction the escaping gases have a temperature of about 950 degrees Fahrenheit, and if the maximum temperature be assumed to be, say, 2700 degrees, the theoretical efficiency would be about 0.533. If now the temperature of the exhaust gases could be usefully lowered to, say, 300 degrees with the same initial temperature, the theoretical efficiency would rise to 0.759, with a corresponding gain in actual efficiency. As it does not seem practicable at present to reduce the final temperature by further expansion in the cylinder, some form of regeneration would probably afford the only means of a closer approximation to the conditions of maximum efficiency.

While the employment of regenerators with engines using city gas is out of the question, the rapidly increasing number of motors working with producer gas would, undoubtedly, admit of the application of the regenerative system with an important saving of fuel. Engines burning Dowson gas in England have been claimed to use less than one and one-half pounds of coal per indicated horse-power per hour, and there is little doubt that this performance has been actually attained. Rankine estimated that ninety per cent. of the heat in the exhaust of an air engine might be retained for further use by means of a regenerator. If now, in the case of a gas engine working in close proximity to the gas producer or generator, an even somewhat smaller proportion of the heat of the exhaust gases could be returned to the producer by means of a suitable regenerator, the fuel consumption would be reduced to less than one pound per indicated horsepower per hour, a result certainly worth striving for. The regenerative apparatus required would be simple and inexpensive, and would require practically no attention. Gas generators working with cold air use about five per cent. by weight of steam with the air blast, and the percentage of combustible in the gas averages forty per cent., with over fifty per cent. of nitrogen. A hot air supply drawn from a regenerator would, however, insure the decomposition of a larger proportion of steam, thus enriching the gas and reducing the volume of useless nitrogen. Obviously there is a chance here for improvement which might be profitably utilized.

A RATHER startling story is told by an engineer who visited the late World's Fair concerning the perfection of the governor of the large McIntosh & Seymour tandem compound engine, which was on exhibition there. The engine, like most of those shown, was furnishing power for electric lighting, and ordinarily carried a load of about 800 horse-power, which was considerably below its full capacity. On one occasion, through a mistake of the switchboard attendant, this load was suddenly increased by something like sixty per cent, and was, a few moments afterward, again quite as suddenly reduced to the original figure without having attracted the attention of the engineer in charge by any change in the working of the engine, or without having in the least affected the various lights on the circuit. Changing the load on the engine by the amount noted and with the result claimed, was about as severe a test of the governor as it is possible to make, and the builders of the engine ought to derive a goodly amount of satisfaction from it. A somewhat similar account was given a number of years ago in regard to the regularity of speed of a straight-line engine exhibited, as it is now remembered, at the Chicago Exposition of Railway Appliances. In addition to a large part of the wood-working machinery on exhibition, the engine also drove a very powerful Edison dynamo. Among the tools was a railroad planer for squaring timber, planing all four sides of a twelve-inch stick at once. This planer, it was estimated, took about thirty horse-power, or between one-third and one-half the power of the engine. Just how much was called for by the dynamo is not remembered, but the experiment of throwing the planer on and off, in order to make the electric lights "wink," was tried several times. So far as could be seen, however, there was no variation whatever in them. Tests of this kind are far more exacting than any that are ever likely to occur in regular work and the fact that they were passed through successfully is decidedly interesting, if nothing more.

John Newton

Nov 17th 1893

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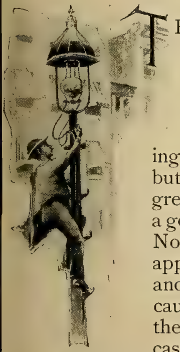
UNDERGROUND ELECTRIC WIRES.

By Professor D. C. Jackson.

Professor Dugald C. Jackson graduated at Pennsylvania State College in 1885, receiving the degree of civil engineer. Subsequently he devoted himself more particularly to electrical studies, and now occupies the chair of electrical engineering at the University of Wisconsin, at Madison.



THE advantage of placing all electric wires underground has been recognized from the very birth of the electrical industries, some of the earliest telegraph lines having their conductors buried; but difficulty of insulation and great first cost have prevented a general adoption of the system. Now, however, the unsightly appearance of over-head wires and the obstruction of streets caused by pole lines, as well as the obstruction to firemen in cases of fire in high buildings, have led the councils in nearly all large cities to compel the electric companies to bury their wires, at least in the most crowded districts.

In a paper on the subject presented at the recent World's Electrical Congress, at Chicago, the author explained that the current methods in the United States of placing such wires underground are divided generally into two classes:

(1) Solid or built-in systems.
(2) Drawing-in or conduit systems.

In the first a conductor, insulated and protected in some way from mechanical injury, is buried and cannot be reached for repairs, except by tearing up the street. In the second class the conductors, either bare or insulated, are pulled into some kind of a conduit. They may be removed or repaired at any time, and additional wires to the full capacity of the conduits may be drawn in as they become necessary. For plants which are liable to grow the drawing-in conduit system has proven altogether the best, and it is always easier to get at breaks and make repairs without delay to the consumer or obstruction in the street. The first cost is slightly greater than that of the built-in system, but usually not enough to balance the advantages. The Edison tube is the only important example of the built-in system in this country, and while it is very successful on low pressure work, the difficulties of maintaining the insulation, particularly at the couplings and junction boxes, for high pressure work, bar it from general competition.

Drawing-in conduits of two classes have been used, insulating and non-insulating, but the former class have always failed to work and have gone entirely out of use for underground work. If a perfectly insulating conduit could be built, into which bare wires could be safely pulled, there would be a great saving in cost, as the insulation of a cable makes up half the cost of an underground system. But since it has been

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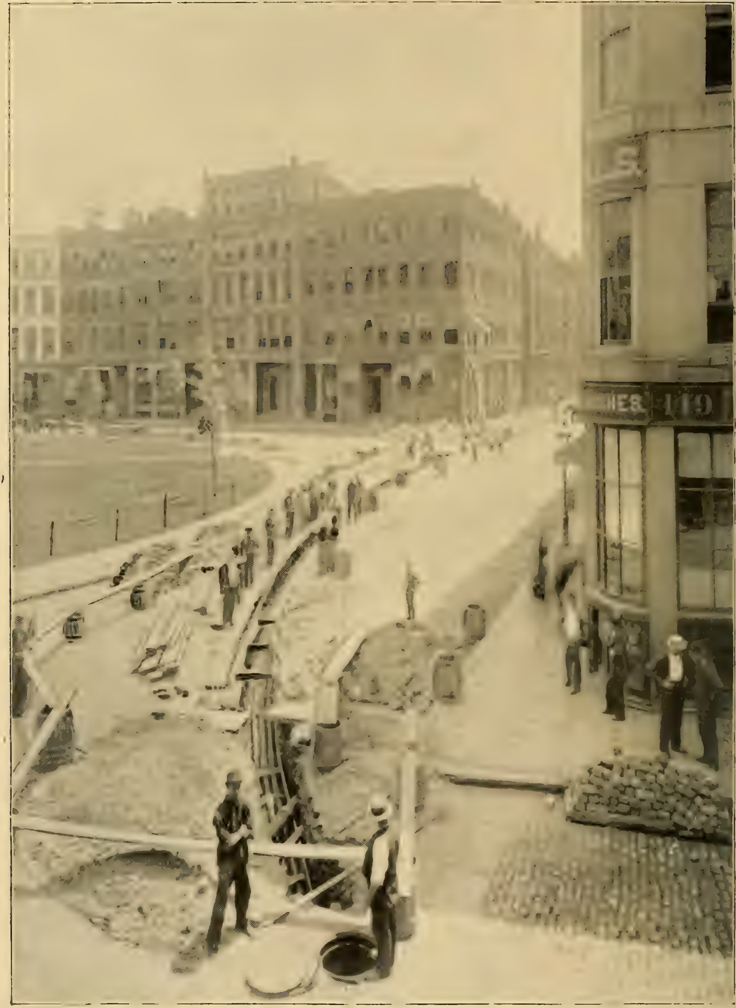
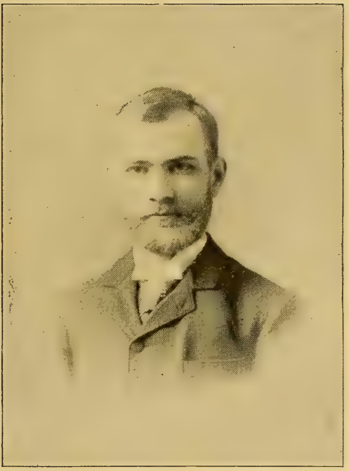


CEMENT-LINED IRON CONDUITS IN FORT HILL SQUARE, BOSTON, MASS

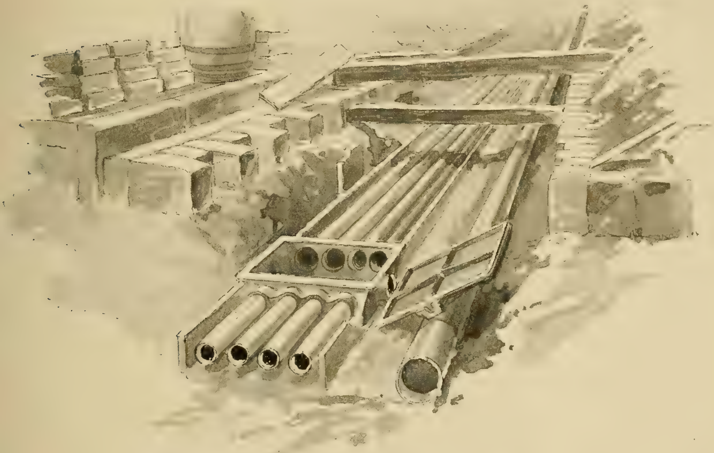


D. C. Jackson

Dec: 15th '93.

found absolutely impossible to prevent the condensation of moisture on the inside of a conduit, the insulation due to the conduit cannot be kept up unless air can be completely excluded, particularly from manholes or junction boxes. Therefore at present the non-insulating conduit system is the method which is generally used for underground wires.

A complete subway system consists of three parts—1st, the conduit; 2d, drawing-in manholes, placed at convenient intervals; 3d, arrangements to get at the cables for the purpose of service connections.

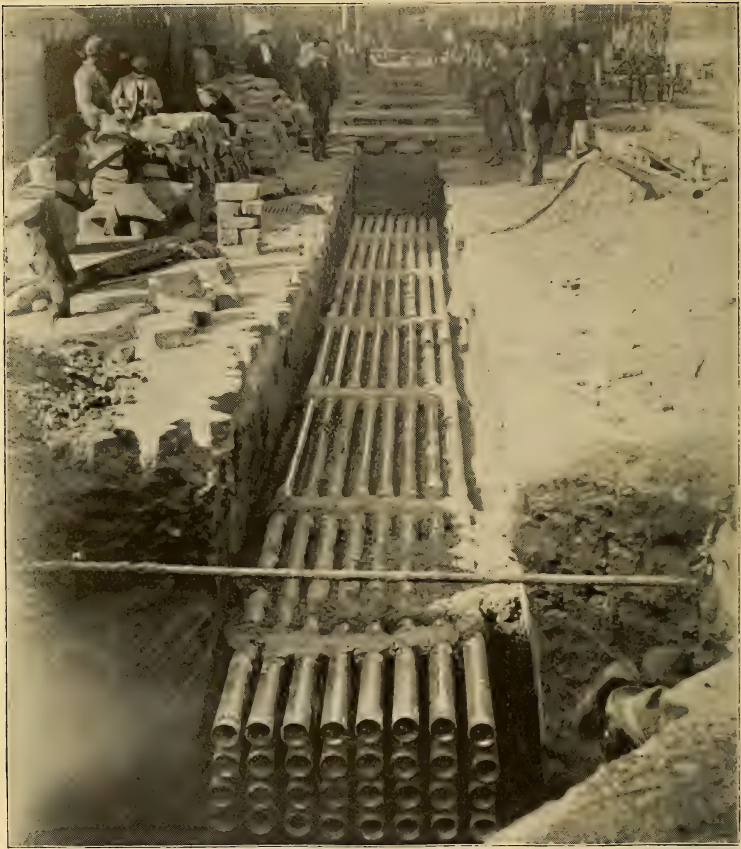


FOUR-WAY DISTRIBUTION, WITH HANDHOLES AND VENTILATING PIPE.

Anything which will keep open a hole, smooth enough on the inside not to injure the cables in drawing in, and strong enough to protect them from mechanical injury for an indefinite length of time, will do for a conduit, provided there be nothing about the material which will injure the covering of the cables.

Of the large number of conduits which have been used or proposed, there are at present in successful use in America on a large scale, four typical forms: Iron pipe, which may be either cast or wrought; cement lined sheet iron pipes; tile, terra cotta, or clay pipes; and wood tubes.

The most generally used are the earthen-ware conduits, and the most used of them are made of glazed terra cotta, in sections three feet long, with one or more rectangular ducts, each capable of carrying at least three cables. The walls are about one inch thick and are supposed to be strong enough not to be cracked by the shock of street traffic when laid eighteen inches below the street surface. Rectangular ducts have a considerable advantage over round ones when the cables are properly drawn in. There is less trouble in drawing in several cables, as they may be arranged to lie side by side instead of on top of one another, and any one may be then withdrawn at any time without disturbing the others. The glaze of the ducts has quite a high electrical resistance, but this is probably a disadvantage, as the cable cover should be continuously grounded to prevent shocks to linemen from static



CEMENT-LINED IRON CONDUITS AT ATLANTA, GA.

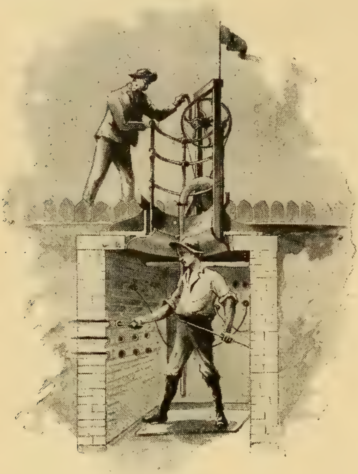
effects, or from leakage. The terra cotta conduit is water-tight and fairly gas-tight when properly laid, but moisture can never be entirely kept out of any conduit, and gas is found to get through even the best built walls, if it is present in the soil in any quantity. The lengths of the terra cotta sections are short enough so that something of a bend may be made in laying, but as the bend is really a series of straight sections, with angles between them, it is rather difficult to pull cables around, and manufacturers recommend perfectly straight ducts. All irregularities on the inner surface are smoothed off before the tile leaves the factory, so that there is no possibility of damaging the cable in drawing in, and there is nothing about the material that could possibly, by any chemical action, injure the lead covering of the cables, or make the withdrawal of the cables difficult after they have been in service a considerable time.

There is a great diversity of opinion as to the proper depth at which a conduit should be laid. The principal conditions affecting this are the presence and location of other pipes and obstructions in the streets; the amount of tearing-up to which the streets are subjected; and the method of distributing wires from the conduits. By some it is claimed that it is well to go below the frost line, but as the material should be one not cracked by frost, this is not usually deemed necessary. City ordinances often affect the position below the streets and then the best is made of what may be unsatisfactory conditions. If it be possible, the depth of the top of the conduit should be about two feet below the pavement, when the conduit is laid in concrete, as at that depth there is no danger of cracking from the weight of heavy teams in the street, as has been the experience where clay conduit has been laid at less depth. If clay pipe is laid bare in the earth (*i. e.*, without concrete) it should be generally about three feet deep for absolute security. The tile conduit should be, and where the best results have been obtained is, laid in a bed of from two inches to six inches of concrete, and covered with concrete to that depth, so that when the whole has hardened it is like a continuous set of stone ducts. The top may be further protected by creosoted board if the conditions make it necessary. Joints between the sections are made either by wrapping the joints with several layers of burlap strips soaked in hot asphalt, or by means of a tile sleeve over the joint which is cemented on. The latter joint is generally used when the conduit is laid in concrete, and in laying the conduit it is then usually sufficient to simply bring the sections together in a line in a trench, and fill in with concrete.

The durability of this terra cotta conduit depends somewhat upon where and how it is laid. If excavations in the streets are frequent there is considerable danger of its being cracked by picks and other tools in the hands of workmen. When concrete is used the conduit will "stand alone," even if all earth be removed from around it for some distance, and ordinary street excavations will not disturb it, but if the excavation is not properly filled in, the whole construction may settle after a time and cause considerable damage. No natural deterioration of this material can take place. It is absolute proof against heat and chemical action, so that, unless it be disturbed, it should last forever.

House services are sometimes taken off from this type of conduit by means of hand holes, in front of each house, using a subsidiary duct of iron pipe running into the basement; and sometimes the service wires are taken from the manholes and carried into each block by the subsidiary duct, whence they are distributed overhead from roofs or otherwise. The all-underground method is the best, but as it is more expensive, it is less frequently used. In either case a subsidiary duct is necessary, and for this iron pipe is undoubtedly best, and is recommended by all manufacturers. If a system has a considerable number of ducts, and hand holes are to be used, the top layer should be used for the distribution mains, so that the services can be readily taken off and shallow hand holes only will be necessary. When for any reason the main conduit is laid quite deep, a separate duct or set of ducts should be run near the surface for distribution. Sometimes, in business districts, it is possible to supply a whole square from a single manhole as the wires can run along under the sidewalks or pass through the partition walls of buildings. The method of distribution is practically the same for any of the forms of conduit in common use except the Johnstone conduit, which may by tapped into anywhere.

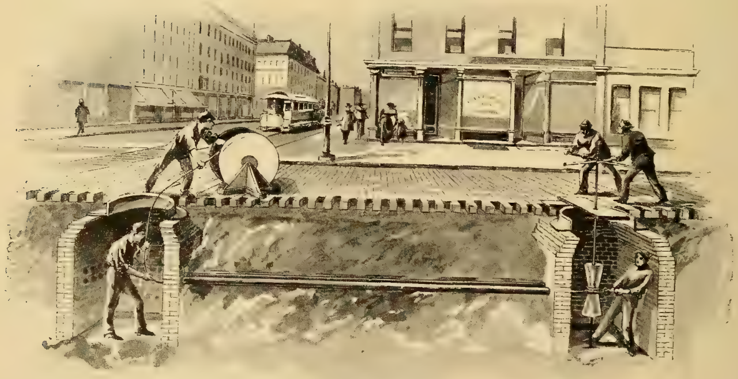
The experience of those who have used tile conduits seems to be very favorable, especially in the smaller cities. In Washington it is highly praised, both by the telephone and electric light companies, and telephone companies in Baltimore, Chicago, Pittsburg, Milwaukee, and other cities consider it successful. In Milwaukee an ordinary cement sewer pipe has been laid in the same manner as the tile, with cemented joints, but no concrete, and it makes a very fair conduit, which is a little cheaper than the special forms. The pipes are softer than vitrified tile, and therefore more liable to mechanical injury, but the system has not yet been long enough in use to fully decide on its comparative merits.



A MANHOLE.

The simplest of all conduits, and one which is used quite generally, is a common wrought iron gas or steam pipe, either laid bare in the ground or in a bed of concrete. Ducts are usually of two-inch to three-inch pipes, and since a three-inch pipe will carry four ordinary electric light cables, the system is economical of space in the streets. One cable can be pulled out when the others are in the ducts, but the practice of handling cables separately when several are in one duct is not advocated by the most experienced. Joints in the pipe are made with a sleeve screwed on with a vanishing thread which is cut so that the ends of the pipe come close together inside the sleeve. The sections of pipe are generally twenty feet long.

When properly joined, the pipe is, of course, water-tight, but gases get into the manholes as in all other systems. The great advantage iron pipe has over all other forms of conduit, is its flexibility. It may be bent in any direction at any point, to avoid obstacles in the streets, and it should always be used when obstacles are particularly numerous. Some authorities claim that a conduit should never bend, but experience in New York and Chicago proves that cables can be pulled easily around



DRAWING IN CABLES.

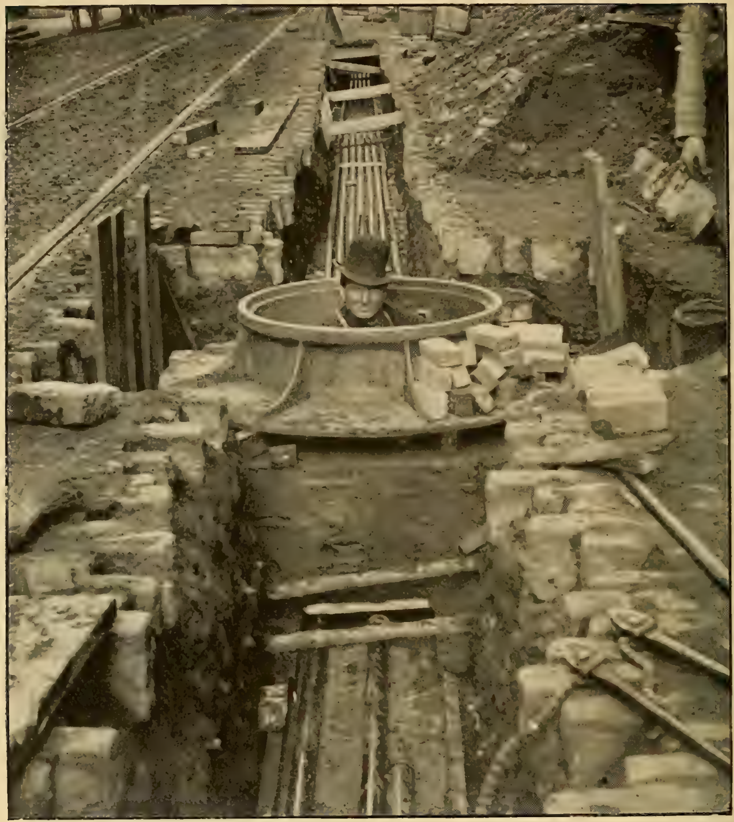
CEMENT-LINED IRON CONDUITS AT PORTLAND, ME.

several bends with radii of three feet or less.

The best method of laying iron pipe ducts is in concrete, with the pipes about one and one-half inches apart. It is sometimes best, as an extra precaution against mechanical injury, to box it in at least on the top and sides with creosoted plank. Pipe may be laid bare in the ground but it is then less durable. Iron has been found to have no bad effects on the lead covers of the cables, either while drawing in, or by chemical action after they are in, although it is possible for rust to so fill up the ducts that the cables cannot be easily withdrawn. The only bad feature of this form of conduit is its magnetic qualities. If an alternating current is carried through an iron duct, and the returning wire is in another duct, the self induction is greatly increased and he loss of pressure is considerable.

An iron pipe conduit is more secure against mechanical injury than any other kind, especially if it be laid in concrete and protected by creosoted planking. It is said by those having experience, that a laborer will try to dig around wood in the ground, when he will try to go right through concrete, so that wood is a considerable protection. Occasionally a crowbar, driven down into the street for an anchorage, will go through plank, concrete and all, but it will glance off the pipe unless it happens to strike very near the centre.

The greatest cause of deterioration in iron pipe conduits is oxidation. The amount of this in conduits cannot yet be determined, as they have not yet been in long enough, but other pipes when laid bare in the earth probably do not keep in good condition more than twenty-five years. If laid in concrete the inside of the pipe only will oxidize,



IRON PIPE CONDUITS AT NEW YORK.

and it is claimed that the pipe might be entirely eaten away and yet leave a smooth duct through the concrete; but considering the quality of the concrete, which is ordinarily used, this is very doubtful. In New York, before ventilating blowers were put in use, a greasy deposit was found on the inside of the conduit, and this seemed to protect the iron, but since the conduit has been thoroughly ventilated to avoid gas explosions this deposit has disappeared and the pipes show the effect of rust to a considerable extent. The distribution of wires from iron pipe conduits is made in a similar manner to that for tile conduits, a special tier of ducts being used for distributing mains only when necessary. The Johnstone conduit is sometimes used for distributing from wrought iron pipe conduits. It consists of cast iron sections five feet long containing two rows of square ducts. This conduit is laid bare in the earth and joints are made fairly tight with plumber's putty. Before every alternate house there is a removable top, and a place in the side of the conduit where a wrought iron subsidiary pipe may be screwed in, making it possible to take off services without expensive hand holes or manholes. This conduit must be laid quite near the street surface. Cast iron lasts better in earth than wrought iron, so that the life of this conduit should be fairly long, but of course the danger of mechanical injury is somewhat greater than in a properly laid wrought iron pipe conduit with concrete. It lacks flexibility and is quite heavy, but seems to be the only distributing system worked out in detail and is quite successful in New York, which is the principal place where it, as well as the iron pipe conduit, is used.

Tubes of wood, treated with various substances to preserve them, have been manufactured by several companies and quite generally used. At present, Philadelphia probably has in use a greater length of wooden conduit than any other city, though there is considerable of it in Chicago and Brooklyn. As used in Philadelphia it is made up of pieces, laid one above another to give any desired number of ducts, and the several pieces are kept in position by dowel pins. The thickness of the walls is about one and one-quarter inches, the top being usually covered with a two-inch plank for extra mechanical protection. The commonest form of wood conduit is made up of four-inch by four-inch pieces of wood with a three-inch hole bored through from end to end. These are joined either by a male and female union or by simply butting the ends together. For a preservative of the wood, oil of coal tar, carbolineum and other compounds have been used. This conduit is by no means water-tight, but with proper cables it has been quite successful. It is less flexible than iron pipe, but curves may be approximated by using short sections. One of the greatest advantages claimed for the wood conduit is its accessibility. The wood may be cut away at any point and connection made to the cables so that expensive hand holes are not needed, but generally when the wooden conduit is used the distribution is made from the drawing-in manholes. The greatest disadvantage of the conduits is the chemical effect of the preserving compound on the lead covering of the cables. The lead is entirely destroyed by chemical action in a short time when in the presence of wood preservative, unless it is protected by hemp braiding, alloying with tin, etc. Since the life of braiding is limited, and tin does not alloy evenly with lead, the rate of depreciation of cables in these conduits is usually great.

The durability of the wood is a matter of dispute. It is claimed that the preservative sinks in deeper with time, making the wood almost bone-like after it has been in the ground a few years, so that it will even turn the edges of the tools used to cut it. From the experience with wood similarly treated and used for other purposes, and what experience has been had with conduits, it seems that they should last at least thirty years, and probably much longer. Untreated wood, which is considerably used in Chicago and elsewhere, will probably not last more than fifteen years. With regard to the mechanical injury from the laborer's pick, the wooden conduit is as safe as any other, but a bar may be driven down through the ducts more easily than through iron pipe. It is claimed in Philadelphia that wood makes the only really successful conduit, but there they have the advantage of a very efficient control of the underground structure which occupies the street, so that its principal disadvantages are not felt.

The only other type of conduit which is being used on a large scale is the cement-lined iron pipe. The tubes for this conduit consist of a tough sheet-iron shell, riveted and lined with five-eighth inch of pure cement, no sand being used, and the inside being carefully smoothed. The pipes are made in eight-foot lengths and of various diameters. The weight per foot of three-inch duct (which is generally used) is about five pounds, as compared with seven and one-half pounds for wrought iron pipe. It is claimed that the pipe is water and gas tight, and proof against acids and alkalies. Distribution is always effected from manholes or handholes, the subsidiary ducts being generally one inch wrought iron pipes.

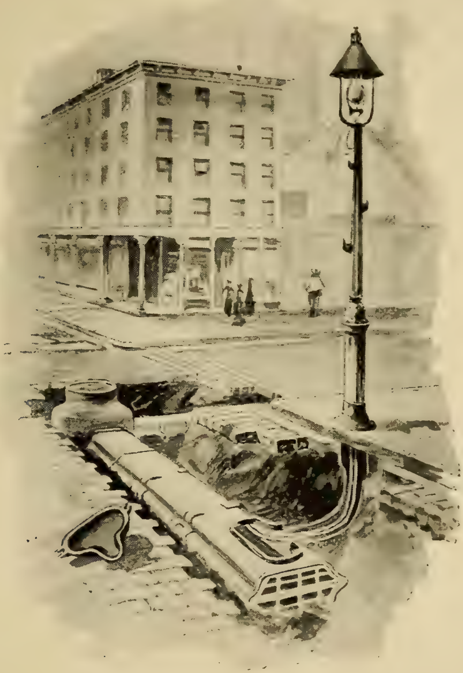
The cement-lined pipes cannot be bent, but some flexibility may be gained by using short sections connected together by ball and socket joints. Bends made in this way must be of larger radius, or cables will not draw in satisfactorily. Clay and wood conduits, as already noted, have the same fault of inflexibility. The cement being smooth inside, this pipe is one of the best to draw cables into that has been tried. It is probable that there is no deteriorating effect on the lead from the cement, although, under some circumstances, it has softened so as to hold cables fast. It was feared that the cement would crack off, but this does not seem to be the case. The tubes are laid in concrete and protected exactly like the ordinary wrought iron pipe.

The danger of mechanical injury is slightly greater than with wrought iron gas pipes. as the sheet iron is too thin to be a protection, but the danger is slight when properly laid in concrete. The cement tube, like terra cotta, should last forever if not mechanically injured, even if the iron becomes entirely oxidized, provided it be true that the cement does not crack or soften. The main arguments made in favor of this style of duct are its durability, smoothness and cheapness as compared with iron pipe.

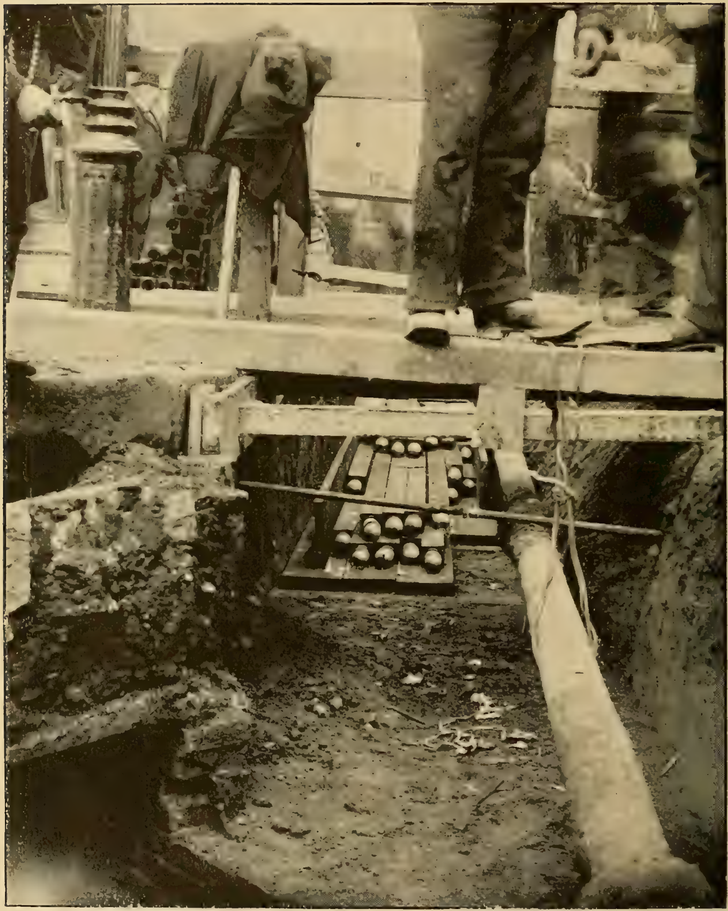
All of these conduit systems are in successful operation on a large scale, but the period of use has not yet been long enough to prove positively that they will all endure satisfactorily. The users of each appear to be well satisfied. Which to choose for any new installation should depend on local conditions. When, as in New York, the streets are filled with a mass of pipes of all kinds, and a conduit may be broken into by a workman at any time, the flexibility and strength of the iron pipe are necessary, notwithstanding its greater first cost and probable greater rate of deterioration. Where underground work is temporary, as at the World's Fair grounds for example, or where cheapness is the main element, the wood conduits are the best. It is probable that their effect on the cable and lack of flexibility balance the arguments in their favor (such as durability, continuity and accessibility), except for the classes of work already mentioned. The arguments in favor of cement-lined pipe are smoothness and cheapness, and it doubtless makes a very satisfactory conduit where the special arguments in favor of iron pipes do not apply. For use where, as in most of the medium size cities of the country, there is still room in the streets for a good-sized conduit without many bends, and where the amount of tearing up of the streets is not excessive, the vitrified clay conduit seems to be best, as its smooth ducts are easy to draw cables into. It does not injure lead, cannot deteriorate in the earth due to any chemical action, and is cheap. The Johnstone conduit is excellent for a distributing system and would probably answer well where comparatively small capacity and no flexibility are necessary.

For electric light cables, especially where several companies occupy the same conduit, larger manholes are necessary. This is a matter which depends altogether on local conditions, which is also true of much else connected with underground conduit construction. An ordinary standard size for manholes is six feet square and seven or eight feet deep. When the conduit consists of a few ducts, near the surface, a much smaller hole, three feet or four feet deep may be used, with a large cover so that workmen can practically stand in the street, while working at the cables.

The walls of the best types of manholes are of brick, laid in cement, and sometimes the whole is coated with cement, but this probably of little value as the character and thickness of the walls is determined by the importance of preventing gas and water from leaking into the manhole and avoiding the destructive effects of the vibrations caused by passing teams. A foundation of at least six inches of concrete should be solidly put in for each manhole, as any settling is apt to throw the ducts out of line, and, in the case of terra cotta, to crack the conduit as well as disturb the street surface. Manhole covers are of cast iron and are placed on a ring casting set on the brick work. This casting should be well fastened down by anchor bolts or something of that kind, to prevent cracks being caused from the effect of vibrations. The covers may be either single or double, but as the outside cover can only be held down by its own weight, and never make a tight joint, the double cover is better if it is desired to keep the hole absolutely clean; but in nearly all cities single covers are used and fair results obtained. In Chicago the telephone company uses a cover with one-half inch slots in it for ventilation, and still has no great trouble from dirt, although it is occasionally necessary to clean out the holes. The best form is where the inside cover is screwed down (much like the manhole cover of a boiler) on a rubber gasket, thus making the hole perfectly tight. The inner cover should be of a form that will drain all water away from the gasket, so that it can be readily bailed out when the hole is to be opened. When the streets of a city are fairly cleaned and well drained, and especially for small holes, the double cover is unnecessarily expensive, but in this case it is well to make the outer cover extra heavy and to use a hemp gasket under it. When double covers are not used, connections from manholes to sewers



THE JOHNSTONE CAST IRON CONDUIT.



CREOSOTED WOOD CONDUITS AT NEW YORK.

are frequently made, and this should always be done where the location is such that there is any possible danger of filling with water.

Some arrangement should always be made for hanging the cables against the sides of the holes, so that any cable can be easily reached at any time, and so that men cannot easily use them for steps in entering a manhole. Manholes made of cast iron sections, creosoted lumber, and of concrete, have been, and are, used to some extent, but the best practice all over the country seems to favor the brick walls, as strongest and best and fairly cheap.

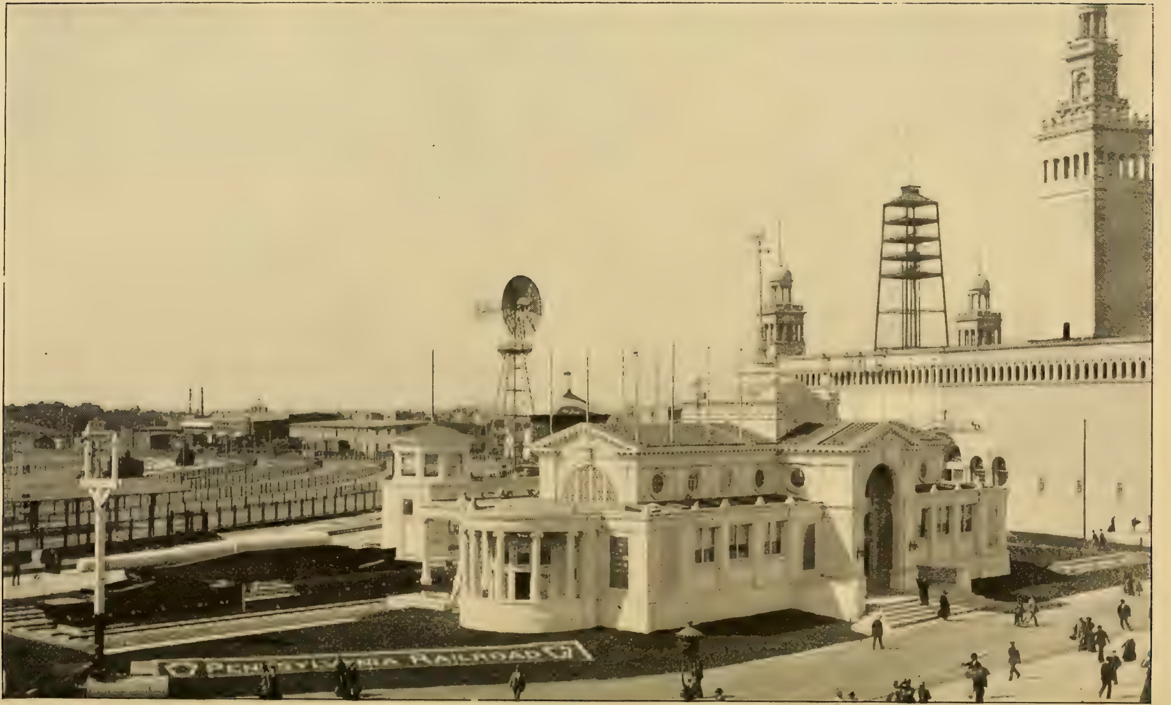
For complete underground house to house distribution some kind of handhole or distribution box is nearly always necessary. It is usually placed at the line of every second lot, two buildings being supplied from each box. Handholes are of two types, surface and buried. The first has a cover like that of a manhole on the surface of the street, and it is, in fact, a miniature manhole, with either single or double cover. The buried handholes have a cover below the surface, and are covered by the paving. When the box is used only for distribution this is probably the best, as it may cost a little less and the pavement must be torn up clear to the hole in any event, when a service duct is to be put in. The presence of the iron covers every fifty feet in the street is objectionable. Handholes, which are simply boxes into which the ducts open on each side, and in which there is a place for subsidiary ducts to enter, are generally about two feet deep, and are large enough so that joints in the cable may be made in them, two inches by eighteen inches being a fair size. They may be built either of brick or of cast iron. In the latter case the castings are frequently ring sections, built up to any desired height.

Some method of draining a conduit is necessary. The ducts may be laid on a slight slope, toward the manholes (which themselves should all drain to one point), and water may be allowed to gather there, to be pumped out occasionally from the street, or sewer connections may be made. The latter are unnecessary if no water can get into the conduit except by condensation.

An even greater enemy than water to the success of an underground system is gas. In nearly all large cities the gas mains are in a leaky condition and the soil is full of gas. If the pressure is any lower in the conduit than in the street, gas will flow in, no matter how tight the walls appear to be. The objections to this are two: first, bad effect on workmen in manholes; second, danger of explosion. The cause of gas in the subways, low pressure, suggests a method of keeping it out; that is, to maintain in them a pressure a little above that of the street by means of blowers.

This method has been a great success in New York. A special pipe (six inches) is laid, connecting the manholes, where openings of different sizes (eighth inch to one inch) are made, depending upon the distance from the blower. A pressure of a few ounces per square inch is kept at the blower and the gas seems to be entirely kept out, manhole explosions never occurring. The amount of air required is about 500 cubic feet per hour for a manhole, the amount for the conduit depending on the kind used. In New York about one horse-power is required at the blower, per mile of subway.

The comparative cost of the different conduit systems is difficult to estimate, as it depends upon so many local conditions. It may be divided into cost of excavation and refilling, and the cost of material and laying the conduits. The first part will vary greatly with the kind of paving, depth of conduit, etc., but is nearly independent of the kind of duct used. The rate of depreciation of a subway has not yet been determined, but from the use of similar materials for other purposes, it may be estimated as being four per cent. or less for iron pipe, and less than that for any of the other kinds if they are properly protected from mechanical injury. The cost of maintenance should be almost nothing, but actual figures for the conduit alone cannot be obtained.

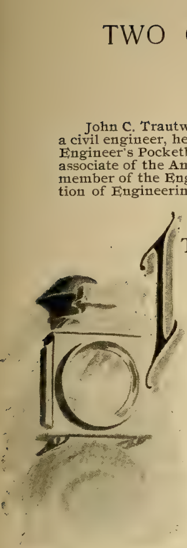


HEADQUARTERS OF THE PENNSYLVANIA RAILROAD EXHIBIT AT CHICAGO.

TWO GREAT RAILROAD EXHIBITS AT CHICAGO.

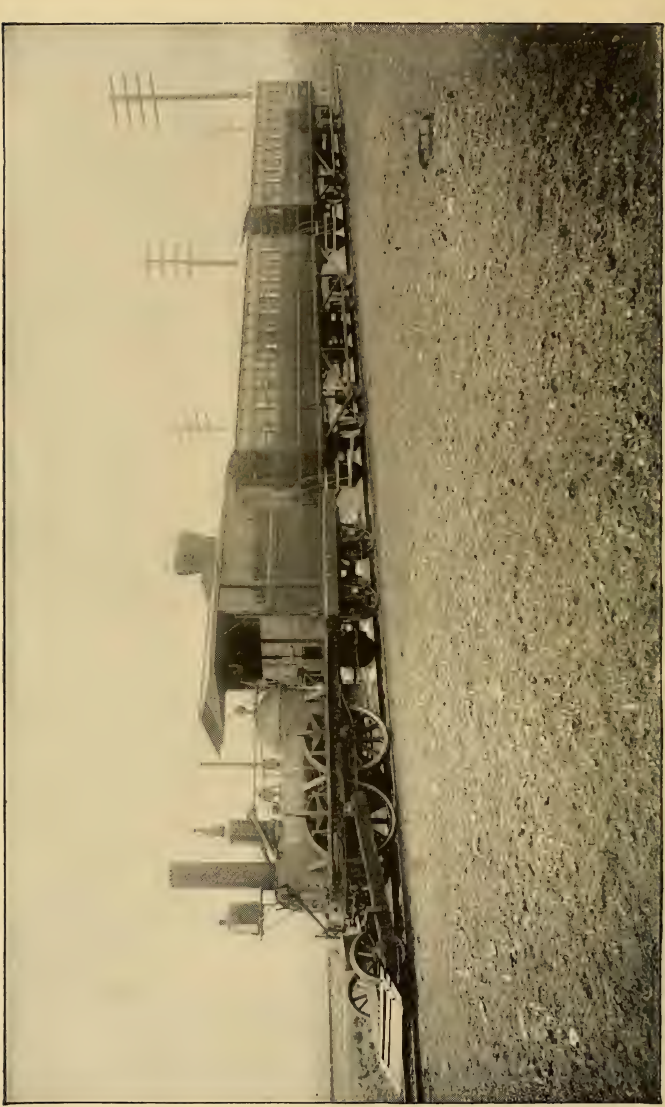
By John C. Trautwine, Jr., C. E.

John C. Trautwine, Jr., was born at Philadelphia on March 17, 1850. Besides following the profession of a civil engineer, he engaged, during the lifetime of the elder Trautwine, in the revision of that author's Civil Engineer's Pocketbook and other works, of which he has since had entire charge. Mr. Trautwine is an associate of the American Society of Civil Engineers and of the Institution of Civil Engineers, of London, a member of the Engineers' Club of Philadelphia and of the Franklin Institute, and Secretary of the Association of Engineering Societies.

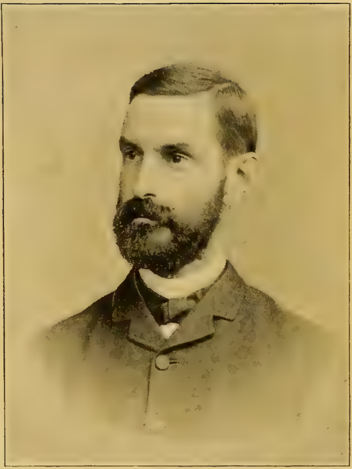


IT would be interesting to know upon what human characteristics Prince Albert counted when he projected the first world's fair—the London Exhibition of 1851. It is easy to understand that the individual trader or manufacturer, and especially the man with a new device, should eagerly avail himself of the opportunities for advertising afforded by such an exhibition, but it is not so easy to divine the motives which lead giant corporations to prepare, at great expense, these elaborate exhibits, especially when the aim seems to be rather to instruct the visitor in regard to railroad matters in general than to vaunt the respective advantages of the particular companies interested. Is it possible that the corporation has, after all, lurking unsuspected somewhere within its hard anatomy the rudiments of what we call a soul? The two exhibits here referred to, those, namely, of the Pennsylvania and of the Baltimore & Ohio railroads, were of extraordinary interest, not only because of their very great extent and completeness, but also on account of their diversity; for while the two are alike in this that they appeal to us less as advertising schemes than as educational institutions, it would be difficult to conceive of two exhibits by railroad companies more widely differing in spirit and in method than are these two. The exhibit of the Pennsylvania Railroad was devoted chiefly to the illustration of its own methods, development and history, and contained a very large collection of objects of the most diverse character, bearing upon these subjects. That of the Baltimore & Ohio Railroad, on the other hand, was devoted chiefly, if not entirely, to the evolution and development of "the World's Railway" (naturally with special reference to the role played by the Baltimore & Ohio), and consists principally of two enormous and homogeneous collections,—one a museum of actual locomotives and full-size reproductions; the other, a gallery of pictorial illustrations. One exhibit may therefore be regarded as supplementing the other, and it would have been difficult to find a more interesting ensemble than the stupendous whole which resulted from their happy proximity at Jackson Park.

Immediately south of the annex of the Transportation building stood what may be called the little white gem of the great White City, the headquarters of the Pennsylvania Railroad exhibit. The building contained most of the smaller objects comprised within the company's indoor exhibit, while just outside of it, to the south, was located the outdoor exhibit. The view of the headquarters given is looking southwest from the platform of the elevated railroad, and taken before the burning of the cold storage house, which is seen just beyond the Pennsylvania headquarters. It shows in how perilously close proximity this invaluable collection stood to the burning build-



THE OLD "JOHN BULL" AND ITS TRAIN.



John C. Trautwine, Jr
Dec. 15, 1893

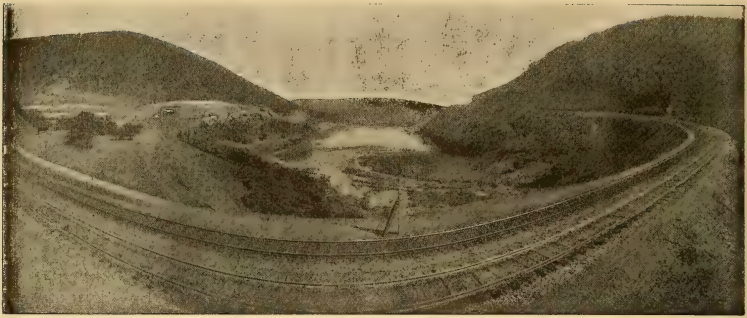
ing. The building containing the headquarters of the exhibit is described, in a catalogue prepared by the company, as "A Passenger Station of Classical Architecture," and, so far as its ground plan is concerned, it is indeed well adapted for use as a station, but it is far too delicately ornate for such a purpose, and there is no reason to fear that the company seriously contemplates adopting this building as a model for its stations. The structure is 140 feet long by forty feet wide, and its length comprises a central hall 100 feet long, and two semicircular apses. The central portion is divided longitudinally, by two rows of ornamental columns, into a nave and two aisles, both vaulted, and running east and west, which are crossed by a central transept joining the two main doors of the building, upon the north and south sides respectively. The nave and transept unite, at the centre, in a graceful dome.

The central hall, or principal portion of the building, 100 feet long by forty feet wide, contains all the objects exhibited in the building. The semicircular annex at the west end contained the passenger office and the bureau of information; while in that at the east end were located the headquarters of Mr. J. Elfreth Watkins, who, under Mr. Thomas N. Ely, chief of motive power, was the special agent of the company in charge of the exhibit. To these gentlemen the writer is indebted for special opportunities of studying it.

Directly under the central dome of the building stood a glass case containing three most interesting relief models. The central and largest one of these, four feet wide by twelve feet long, was the first and only relief map made to represent the strip of country embracing the Allegheny Mountain district from Altoona and Hollidaysburg on the east to Johnstown on the west,—a strip about thirty-three miles long by one-third that width, and embracing the passage of the Allegheny Mountain range. The elevations were shown to a scale of one inch=400 feet, and the plan showed not only the present line, with the celebrated "Horse-Shoe Curve," about five miles west of Altoona, and the Gallitzin tunnel at the summit just beyond, but also the locations of the old and new lines of the Portage Road built in 1832 and 1852 respectively, with their inclined planes, together with numerous branch lines. The portage railroads were used for the transportation of the boats of the old Pennsylvania Canal, and also accommodated local traffic in private cars. The plan showed also the location of Johnstown, together with that of the South Fork dam, the bursting of which wrought the ruin of that town in 1889, and the South Fork and the Little Conemaugh rivers, by which the flood poured down upon its victims.

Of the other two, and smaller, models, which flanked the one just described, one represented "Plane No. 1" of the Old Portage road, about four miles east of Johnstown, at the head of which was represented the entrance to what is claimed as the first railroad tunnel constructed in America, while a canal boat, in sections, was represented ascending, and a train of cars descending, the plane. On the opposite side of the Little Conemaugh, in the same model, was shown a piece of the present line, crossing the new stone bridge, built to replace one carried away by the Johnstown flood. The other one of the two smaller models represented the horseshoe curve, with the Limited express ascending and a freight train descending the heavy grade there. The model showed the Limited as being hauled up by only two engines, and this indeed suffices for that train, but no less than four engines, including one of the new Schenectady compounds, was attached at Altoona to climb this grade with the heavy Columbian express of seven Pullmans, two vestibule day coaches and one vestibule baggage and smoking car, which brought the writer from Philadelphia to Pittsburgh, en route for Chicago.

West of the relief plans just described, and still in the longitudinal axis of the building, stood a glass case containing a model of one of the large and palatial



THE HORSE-SHOE CURVE NEAR ALTOONA, PA.

ferry-boats recently added by the company to the fleet by means of which, until the completion of bridge or tunnel, it must continue to effect the passage of the Hudson river between New York and Jersey city. These boats, as all New Yorkers and some Philadelphians know, constitute a very radical departure, at least in one important respect, from what has always been considered orthodox ferry-boat practice, in that, following, I believe, the lead of the Hoboken ferry, they have departed from the time-honored paddle-wheel and walking-beam and have substituted therefor the screw system. Indeed, the system as there shown applied to a ferry-boat, differs also from the usual screw system in that the screw shaft of the ferry-boat extends from end to end of the craft and is armed with a propeller at each end. A mirror, placed under the model, showed the bottom to good advantage. Another unusual, though not unprecedented, feature of these boats, is the commodious and elegant upper deck, by which, in conjunction with the elevation of the tracks in Jersey city, and the construction of the bridge over West street, New York, the passenger may pass directly from the station platform in Jersey city to Cortlandt street, New York, or *vice versa,* without attempting the muddy and perilous passage of West street. The model, which measured eight feet by two and a half feet, being built to a scale of one twenty-fourth, is, in the words of the catalogue, "complete in every detail of hull, decks, joiner work and furnishings," and is "arranged to be lighted with electric lights in the interior."

In striking contrast with this was a drawing of the old ferry-boat worked by horse-power, used sixty-five years ago on the Delaware between Philadelphia and Camden. The drawing was made by the father of the writer in 1828, when eighteen years old, at the request of his employer, William Strickland, for exhibition to Jesse Hartley, of the Liverpool Docks, who was then visiting this country.

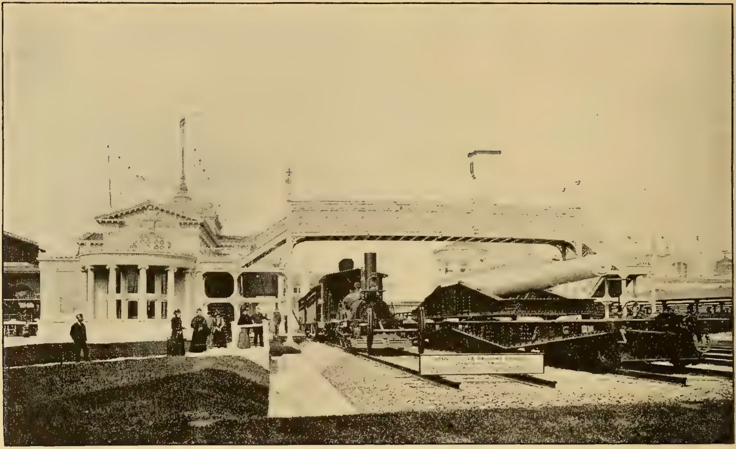
Next to the model of the ferry-boat, stood a model representing one of the company's tugs, such as are used in New York harbor, towing a car-float containing ten freight cars, representing not only the company's equipment but also those of the affiliated Union and Empire lines. Just east of the dome was a papier maché model of the globe, two and one-half feet in diameter, around the circumference of which extended three grooves. In those grooves moved respectively three little images, one of a seated passenger, one of a locomotive and one of a coal car. These images were intended to traverse the circumference in seven and three-quarter minutes, in two hours and in sixty-three seconds respectively, and would, no doubt, have done so, had not the model met with an accident on the journey hither. As it was, their movements were unfortunately somewhat erratic. The model was intended, of course, to illustrate the passenger, locomotive and freight mileage of the company, which reach, respectively, about 4,600,000 passenger-miles, 293,000 engine-miles and 36,000,000 ton-miles, per day.

Just north of this again, was a chart of the Pennsylvania system, including the lines west of Pittsburgh. The chart was about ten feet high and thirty-three feet long, bent into horse-shoe form and maintained in an upright position so as to form a little room in itself. To this model were affixed tiny figures of locomotives cut out of gilt and blue metal, and so placed as to form a record of the positions of all the company's engines at 6 P.M., Eastern time, on Columbus Day, October 21, 1892. At that time there were in motion upon the Company's lines about 850 locomotives, or, including switch engines, about 1100, which is a little over one-third of the entire equipment. Beyond this map was a wooden working model of a link motion used by the Madison & Indianapolis Railroad in 1862, to explain that device to its engineers and firemen.

At the east end of the nave were well executed life-size and quite life-like figures of five of the company's "standard" servants: the conductor, the unintelligible brakeman, the ferry-boat pilot, the baggage master, and his chief of staff, the rich but honest porter, the latter of a color that would bring a blush to the cheek of the end-man himself. Each of those magnates is of course in full uniform, and, like the saints in mediæval paintings, each is armed with his characteristic weapon, or the instrument of his martyrdom. The conductor has his lantern, the brakeman his red flag, the pilot his silver buttons, the baggage master his bunch of checks and the porter the passenger's trunk. The conductor originally held also a limited Chicago ticket (expired) and a ticket-punch, but these were removed by some kleptomaniac. Now that the brakeman's occupation, as such, is gone, thanks to the introduction of the air-brake, is it not in order to look forward to his withdrawal in favor of the phonograph. Or must he continue on the force, in order to make those inexplicable journeys to the rear with his red flag when a train is blocked, only to take his choice between getting left himself and having his train left unprotected as he hobbles back to it when the four whistle blasts blow?

Upon the floor and on the north side of the nave were also, in glass cases, maps of Philadelphia and of the Hudson river at New York, each showing the company's terminal facilities and having the principal buildings shown in relief. In the building stood also two large shields, each about seven feet high and in the form of a keystone, the emblem of that State from which the company takes its name, and in which, naturally enough, it has by far its greatest mileage. One of these shields contained a diagrammatic list of the principal officers of the company, showing its organization and the relations of the officers to each other and to the stockholders. The other shield must have been of the deepest interest not only to the capitalist interested in railroads but also to the student of political economy, for it contained plaster casts of the seals of the 218 railroad corporations which have gone through the process of absorption into the great Pennsylvania system. Whatever views may be held as to the social and political advantages and disadvantages of such a system of amalgamation as is here indicated, the bitterest foe to the extension of corporate power can hardly deny, or the weakest intellect ignore, the enormous present gain to the traveling, if not to the shipping public, which it brings to pass. Admitting that it gives to the great corporation an unwholesome degree of power, the gain in the convenience of the system must at least be accepted as an offset.

Attached to eight of the columns which separated the aisles from the nave was a series of nearly two hundred hinged frames, containing a wealth of



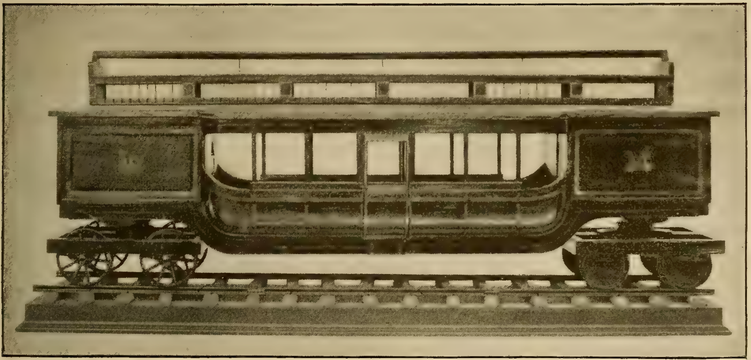
THE PENNSYLVANIA STANDARD TRACK EXHIBIT.

documentary relics, written and printed, and of old and new lithographs and photographs of the company's routes, the scenery, and the towns and cities passed through, the manufacturing establishments served, the rolling stock of the road in various stages of its development, etc., etc., which our limits will not even permit us to summarize, and the gathering of which in so short a time must have required not only a wide knowledge of men and of their possessions, but also a remarkable willingness on the part of the men to part company, temporarily at least, with those possessions. Mr. Watkins is enthusiastic in his praise of the cordial liberality with which his associates in the company's service came to his aid in this matter.

Among the objects displayed in the frames attached to the columns there was, perhaps, nothing of greater interest than a series of documents which go far to confirm the claim of Robert L. Stevens to the credit of the invention of the T rail, so commonly known as the Vignoles rail in Europe. Not only were the invoice and the bill of lading for the first shipment shown, together with a bill of £20 for turning the rolls, but letters from one Ogden, Stevens's representative in Liverpool, to his principal, in one of which he refers to Vignoles as having used the Stevens pattern and expressed his approval of it.

The north and south walls of the central room were lined with cases containing a most valuable and interesting collection of relics and models, forming an exceedingly instructive lesson in the history of railroads, from the prenatal stage to the present day. There was the old Conestoga wagon, answering, in its double capacity, to the present emigrant and freight trains, and taking its twenty days to get from Philadelphia to Pittsburgh, and the stage coach used at the same time for "first-class" passengers. There were canal boats for freight and for passengers, some of them divided transversely into three separable sections for convenience in climbing the inclined planes of the portage ; locomotives, including the old Stockton & Darlington "No. 1," the model of which was brought from England to America by William Strickland in 1826, and loaned for this exhibit by the Franklin Institute, of

Philadelphia; the old "John Bull" and train in their first estate, the John Stephens "Monster," with its single pair of seven foot drivers, and the rack-rail engine of 1848, with horizontal driving and vertical rack-rail cylinders, for the Madison plane; and cars of various patterns and ages from 1831 to 1849, including the "Victory," a gorgeous vehicle which ran from Philadelphia (as it then was) to the ferry over the Schuylkill at the site where the old Columbia bridge (a model of which was shown) was afterward built, and where the iron bridge built by the Phœnix Bridge Company for the Philadelphia & Reading railroad now stands. To quote the catalogue again, "This was one of the first passenger cars built with trucks (or bogies)," and its deep car-body, hanging down between the unusually large wheels of its trucks, suggested the great Estrade railway carriage, with its eight-foot wheels, exhibited at the Paris Exhibition of 1889, and reminded us that many a good thing, born before its time, is doomed to desuetude until the favoring conditions obtain which are needed for its development. The "Victory" affords, in the drinking bar with which it was provided, a curious illustration of the extent to which the early railroad adopted the methods of its predecessor, the steamboat.



THE "VICTORY," ONE OF THE FIRST PASSENGER CARS BUILT WITH TRUCKS.

Then there were models of switches and signals, ancient and modern, apparatus for color blindness tests, telegraph instruments manufactured by the company at Altoona, documents relating to the Pennsylvania Railroad Voluntary Relief Department, and the Pennsylvania Railroad Young Men's Christian Association, and a host of relics of such rare and touching antiquity that we found ourselves prone to forget that there are to-day in active business men who remember it all. One of these cases contained the check for $14,949,052.20, drawn June 7th, 1881, by the treasurer of the Pennsylvania Railroad Company on the National Bank of Commerce, New York, in payment for the plant of the Philadelphia, Wilmington & Baltimore railroad, which then passed into the hands of the Pennsylvania, adding another, and one of the most important, to the collection of seals of merged corporations. It is claimed that this is the largest check ever drawn in the United States and we find no difficulty in believing it.

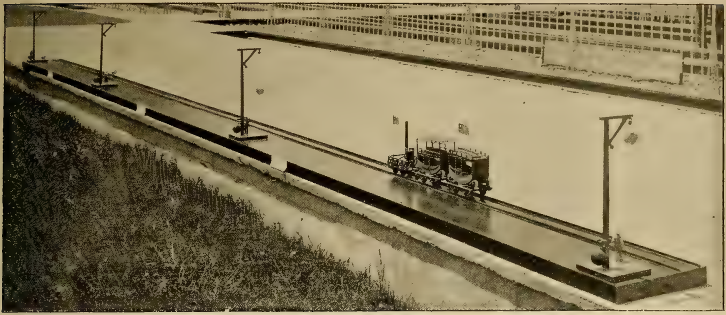
The cases also contained a series of interesting statistical models, designed to illustrate facts connected with the company's operations and the dimensions of its plant, such as a couple of rail sections, with silver dollars laid touching each other along their tops, indicating that the capitalized value of the company's plant is equal to the face value of the silver dollars it would require to line all of its rails in this way; a pair of square pyramids, three inches on a side, one of them of the proportions of the great pyramid of Cheops, and the other about twenty-four inches high, or about thirteen times as tall, representing, to the same scale, the volume of ballast on the company's lines; a miniature oil well, with machinery in motion, to impress the fact that the company consumes the entire product of a well producing 375 barrels per day; a reservoir and watering station accompanied by a card stating that the company uses as much water as either Naples, Baltimore, Washington, Boston, St. Louis or San Francisco would use at fifty gallons per head per diem.

One of the most interesting objects in the collection contained in the side cases is the model illustrating what appears to have been an old system of block signaling used on the New Castle & Frenchtown road. This primitive single track railroad connected the towns of New Castle, on the Delaware river, with Frenchtown, on the Elk river, a stream flowing into Chesapeake bay, and formed an important one of the many links in what was then practically the only chain of communication between the northern and southern cities of the Atlantic seaboard. It was opened for traffic in 1832. The five signals used on the road were about four miles apart, or only so near together as was necessary for distinct vision by means of a spy-glass, for this was in pre-telegraphic days, and this railroad, like the coach "Victory," with its bar-room, had to be content to borrow ideas from the marine as well as from the coaching world. Each signal post was provided with two large balls, one white and the other black, which were raised and lowered by ropes. The nearest signalman, as shown in the illustration on the opposite page, has raised the white ball to the top, to indicate that a south-bound train has entered his block; the second has the white ball at half-mast, indicating that the train is approaching him; the third is preparing to raise the white ball when necessary, while the fourth is taking a peep through his telescope at the third.

The illustrations on pages 190 and 191 represent the "lap-siding" in use on the single track portions of the company's lines west of Pittsburgh and illustrated in the exhibit by the model shown. The device consists of two sidings, one on each side of the road, and so located that their meeting ends overlap. By this arrangement any number of freight trains, marshaled on the two sidings and all heading toward the lap, may proceed at once upon their respective ways along the main line immediately after that line has been cleared, as by the passage of a passenger train. The two switches and their respective signals are controlled from a single signal tower, and their position is indicated by the position of the pair of switch levers shown in the illustration on page 190.

The section of track and roadbed outside the building consisted of four lines of track, the two outside lines for passenger and the two inside for freight trains, the freight lines being separated from the passenger tracks by light wrought iron fences provided with gates. In a truly prophetic spirit this bit of "standard" road was laid with 100 pound rails in lengths of 100 feet, with fifty feet lengths at the ends where necessary. These rails were rolled by the Maryland Steel Company, at Sparrows Point, evidently for the purpose of the exhibit. The ties were of oak, and were laid in a bed of rock ballast.

The two passenger tracks were continuous throughout, but the two freight tracks were connected by a cross-over with frogs and trailing point switches from the works of the Union Switch and Signal Company, at Swissvale, Pa. This afforded opportunity for the display of the new Pennsylvania Railroad standard electro-pneumatic signaling



AN OLD SYSTEM OF BLOCK SIGNALLING ON THE NEW CASTLE AND FRENCHTOWN RAILROAD.

system, erected by the same company under the Westinghouse patents. The system has already been installed by the Pennsylvania company at Jersey City, at Pittsburgh, and in connection with the enlargement of the terminal facilities at Broad street, Philadelphia. Its distinguishing feature consists in this, that whereas in the ordinary system the movements of the switches and signals are governed by long levers acting mechanically through a system of rods or pipes and bell-cranks, the switches and the signal arms in the new system are moved directly by compressed air working upon pistons in cylinders placed immediately under, or alongside of the switch or arm to be moved. In the signals, the movement of the piston is communicated directly to the short arm of the lever by means of a rod. The supply of air is brought to the cylinder in small pipes from a condenser or accumulator in any convenient location, and the valves controlling its admission to and escape from the cylinder are placed in the body of the cylinder itself. They are operated by a powerful electro-magnet, placed there also, and the magnet is operated by an electric current, generated ordinarily in a storage battery placed in the signal tower. The current is controlled by small hand levers, and the signals and switches are thus operated with an inconsiderable fraction of the power necessary to work the levers of the old system. The outdoor exhibit contained also the first interlocking apparatus brought to this country. It was imported in 1873, and was used at Harrison, near Newark, N. J., from 1874 to 1891. Here also were wooden car wheels with iron tires, from the Camden & Amboy railroad of 1847-8, samples of old roadbed from the Portage railroad, with stone blocks under the rails and occasionally with stone cross-ties, and other historic bits from the Maintenance of Way department.

To enable passengers to pass from one side of the road to the other without crossing the tracks at grade the Pennsylvania generally employs a tunnel under the roadbed, inasmuch as a smaller ascent and descent are required to go down and through the tunnel than to go up and over a bridge by about as much as a locomotive is taller than a man, but it was found impossible to use a tunnel in connection with the Chicago exhibit, as water was struck very near the surface. Hence, resort was had to a bridge. A small model of a tunnel or a subway crossing had, however, been prepared for the exhibit, in order that the more usual method might be illustrated also.

The booth in the Transportation Annex, devoted to the illustration of the company's department of chemical and physical tests, contained several car wheels, and an axle which had been tested with various results, some being

LAP SIDINGS ON A SINGLE-TRACK LINE.

tested to destruction, and samples of various materials that had been submitted to the several tests required. One of the car wheels, cast at the company's Altoona shops, placed in service under a passenger car at Philadelphia, May 6, 1886, and tested by actual service on the road only, ran for nearly seven years, making a mileage of 146,188 miles, and it was apparently in good running order still. Samples of the company's standard oils, etc., were also shown. The department was established over twenty years ago. It deals with the development of the locomotive and of other rolling stock, the quality and economical use of fuel and other supplies, the investigation of electrical machinery and methods, the sanitary care of the road and of its employees, etc.

Of the four cars exhibited, one was a vestibule day coach of the company's new standard pattern, heated with steam from the engine and provided with windows and blinds operating upon a new principle, which promises an important reduction in the volume and intensity of railroad hot weather profanity.

A refrigerator car, with one end removable, showing the receptacles for the ice, with the arrangement for securing a circulation of air, illustrated the practice of the Pennsylvania in this respect. The Union line, controlled by the company, is said to have been the first to introduce the refrigerator car, without which the shipment eastward and the exportation of dressed Western meats, and Western and Southern fruits could never have attained their present dimensions, if, indeed, they could have existed at all. Next followed a track indicator car. This is so arranged as to record automatically the condition of the track as to gauge, surface and super-elevation, and also the speed of the train. One of its axles has a large and a small pair of wheels, which by means of an arrangement of levers and springs, record the above-named elements upon a strip of paper about a foot wide, which passes through a machine provided with a series of stylographic pens and placed within the car directly over the truck referred to. The smaller pair of wheels has a divided axle, working telescopically by means of a spring at its centre, and serves to record the gauge of the road, while the larger pair records the surface character of the rails.

The super-elevation is recorded by means of a pendulum free to swing transversely of the car, but designed to hang vertically at all times. A track-inspection car completes the exhibit. In the front portion of this car the floor is practically a series of steps, each having an ordinary double car seat on each side of the car. By this arrangement each seat, except the last one on each side of the car, is raised above the one in front of it, so that each occupant of the car, except those on the last two seats, has an unobstructed view ahead. The side windows in this portion of the car follow the ascending scale of the seats, and thus reveal the arrangement of the latter to the outside world. On the sides of the car are receptacles for blanks upon which the inspectors record the conditions of the various sections as observed by them.

It seems not only surprising, but most regrettable, that this company, which perhaps leads all others in the matter of equipment, and which builds 300 locomotives annually at its great Altoona shops, should have made so meagre a display of its cars and none whatever of its engines. In a building crowded with locomotives and cars of all makes and of all roads, as is the southern end of the Transportation Building Annex, this omission was conspicuous and might have led the uninitiated to infer that the company's rolling stock was not of a character for exhibition and that it had no engines of its own make.

FREIGHT TRAINS ON LAP SIDINGS, READY TO ENTER THE MAIN LINE.

(*To be concluded.*)

THE ECONOMIC ELEMENT OF TECHNICAL EDUCATION.

By L. S. Randolph, M. Am. Soc. C. E., M. Am. Soc. M. E.

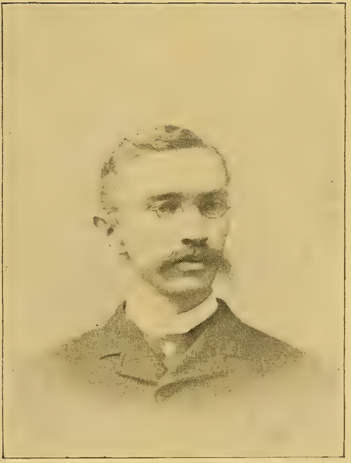
Professor Lingan Strother Randolph graduated at Stevens Institute of Technology in 1883, subsequently became Superintendent of motive power of the Cumberland and Pennsylvania Railroad, and now occupies the chair of mechanical engineering at the Virginia Agricultural and Mechanical College.

SLOWLY and surely has the engineer grown in knowledge, in experience and in usefulness from the savage who first used the limb of a tree for a lever, to the builder of a cantilever bridge; from the constructor of the first raft to the designer of the modern trans-Atlantic liner. The instruction of our young men in the science and art of engineering, like everything else, follows this universal law of evolution, from the merest rudiments of mathematics and physics to the elaborate organization and paraphernalia for teaching the application of mathematical and physical laws of a modern school of engineering. The great names which have adorned the history of engineering were of those who, having the constructive faculty largely developed, built, as best they could, that which was required of them, often insecure, often crude, often abnormally expensive and yet often better than they knew. To these men the problem was not so much what a structure would cost, but to build a bridge which would not fall down, a dock which would stand the buffets of ships and waves, a structure which would be enduring and servicable alike. How well they have succeeded, the monuments which they have left to us attest.

It is with all reverence and humility that I thus speak of those who, by the boldness of their genius, astonished the world, and who set an example of problems solved and work done with facilities sufficiently inadequate to daunt the boldest at the present day. To these men the certainty and accuracy of their calculations as to the strength of a beam was of far more importance than its cost; the strength and distribution of the strains in a bridge of far more moment than the relative economy of different styles of trusses. To-day we are met by an entirely different set of conditions.

One can buy, by the yard, strain sheets of bridges, roofs and other framed structures of all kinds and for all conditions of service; for a few dollars a full set of designs can be had for different types of locomotives; the strength of materials has been carefully worked out and books can be had for the asking, giving the strength of beams, girders, etc.; the efficiency of prime movers has been carefully determined, and the data thereon can be readily obtained. One does not now design a turbine wheel or a steam engine unless directly in that business, although one may thoroughly understand the subject; but, looking up the results of tests, one selects the engine best adapted to the work to be done, and goes to the manufacturer for the outfit complete. The question now asked is, not if a process can be devised for accomplishing certain results, but which of a number of methods is the best, and by best is meant the most economical.

This brings up two questions which it behooves the technical school graduate to answer to himself before he starts into the practice of his chosen profession. First, What is the cost of the different items most likely to come into his line? Second, What degree of complexity or refinement of workmanship and design is necessary or justifiable? No more exasperating thing can occur to the young graduate coming



L L Randolph
Dec' 15 '93.

forth with his brain filled with visions of thermodyamics, co-efficients, neutral axes, radii of gyration, etc., than to be asked the price of a six-inch pulley and have no idea of the answer nor know where to get the information ; or to be asked the relative value of two different types of engines and to find, after having given their water consumption or their economy based thereon, that their relative value from a commercial standpoint was wanted, or the cost per horse-power, day or year. I doubt if there are very many engineering schools in the country where the pupils are taught when to use a compound engine or when to use a condenser.

Many an elaborate plan and many a well laid scheme has fallen through because of the commercial element having been entirely neglected or not thoroughly understood. It will be argued, and justly so, that a student can not cram his head with a mass of data whose value is as constantly fluctuating as the prices of different machines and their parts, but their value can be economically determined and retained, and the economical principles of the machine business can be readily taught.

I would recommend a system or course of instruction in shop and construction, accounts and bookkeeping, together with the methods of determining the cost of construction, and practice in estimating; in bridge work, the method of determining the cost of a bridge, with the variation of price dependent upon the variation of span and weight of bridge ; in shop work, shop accounts, piece work versus day work, arrangement of tools and buildings with relation to the work to be done. It will not be possible to go into all the details of this subject, but the fundamental principles can be very readily covered.

This brings us to the second question—what degree of complexity or refinement of workmanship is it economical to use? Some one says, "Do not put a crocus finish on a hand car crank," and the phrase, though homely, contains the substance of the whole matter. Work should never be done any better than the importance of the subject demands. The man who would carefully file and polish a piece of machinery which was to be left exposed to the weather would deserve the highest censure. It will be argued that these generalities are all very well, but how can they be placed before a class of students so as to give a retainable idea. The writer confesses the justness of the criticism and his own inability to do more than give a few illustrations which may, perhaps, convey his meaning to some one better versed in the science and art of teaching and better able to obtain practical results.

Well does the writer remember his first lesson on this subject when standing between two large pumping engines of approximately the same capacity, the one an elaborate beam engine with fly wheel giving a duty of 110,000,000 foot pounds, the other a direct acting engine with a duty of only 70,000,000. He was told that the interest on the difference in cost would have paid three times over for the coal saved by the larger and more expensive engine.

On one of the most noted of our railroads the cost of repairs was given a few years ago at six cents per locomotive mile, while on a neighboring railroad, giving just as good locomotive service, the cost was only four cents. I imagine that it would be difficult to show good engineering in this.

Not so many years ago locomotives were sheathed in brass as to cylinders, steam chests, and even boilers and stacks. Landscapes of varying degrees of artistic merit were painted on cabs and tenders with the result that it cost more to clean the engine than it did to fire it. The present method of finishing and painting locomotives is far more artistic and satisfactory.

A small weir, recently made for the writer, was filed out to within one hundredth of a inch of the dimensions given. As the measurement of the depth of water on the weir was to be taken with an ordinary foot rule the probable accuracy of which was to within one-sixteenth of an inch, the extra refinement put on the work was of course useless.

Another case recently seen was that of a gauge for angle splice bars where an accurate gauge was made for the back or outside of the angle splice bar, which would fit by no possible chance more than once in a hundred times on the ordinary angle splice and where it would have made no difference whether it fitted or not, as the nut of the track bolt only came against it.

An engineer building a logging road or other temporary structure would be justly censurable should he carefully calculate out the dimensions and have the timber for a trestle carefully cut to those dimensions rather than take the first rough and sound timber which came to hand, whether sawn or otherwise, which could be readily and cheaply obtained and was not too small to carry the load, or too large to be handled readily. The engineer for a large railroad or bridge company, on the other hand, could afford to have his timbers carefully cut to the desired dimensions, even going so far as to carry duplicate parts in stock. The bridge engineer also calculates the dimensions which the members of a bridge should have and takes the next largest merchant size, knowing that the expense of having the bars rolled to the calculated size will be much more than the cost of the extra metal used. These calculations are carefully made and checked, but the man would deserve severe censure, and would undoubtedly get it, who would have his false work gotten out as carefully, rather than use what he had on hand or purchase with a view to future use elsewhere.

Let it ever be kept before the student that the profession of an engineer is essentially a commercial one, and that he must build no better than the exigencies of the case demand. He is a middle man between the producer of facts and the consumer ; between the scientist and investigator and the business man, and that to succeed he must combine, to a certain extent, in his own person the qualities of both. Heretofore engineers have gone to the former as being more interesting and attractive, but the business side must be fully developed if success be desired. The true definition of an engineer is "one who adapts the discoveries of the scientist to the structural needs of mankind."

The law of evolution is universal in its application and that institution which first pushes into this field and develops it as it can be developed will find a marked increase in the demand for its product and an improvement in its rank among the educational institutions of the world.

E. W. Leavitt

Dec 6th. 97

SOME ANOMALIES IN STEAM ENGINE DESIGN.

By Dr. E. D. Leavitt, M. Am. Soc. M. E.

Probably few American engineers have so widely-established a reputation as Dr. Erasmus D. Leavitt. Born at Lowell, Mass., in 1836, he received his early education in the public schools of that city, subsequently going through a varied engineering experience until, at present, he stands in the front rank of his profession, his best work, probably, being seen in what he has accomplished as the consulting and designing engineer of the Calumet and Hecla Mining Company. To Dr. Leavitt belongs the credit of being the first in America to inaugurate a marked advance in the economic duty of pumping engines for supplying cities with water.

PREVIOUS to the year 1870 there were few, if any, examples of compound rotative engines in the United States. Within the three years following, two Massachusetts cities installed pumping engines of the compound beam and fly-wheel type, each of which had a capacity of five million United States gallons per twenty-four hours, raised against a head, including force-main friction, of approximately 161 feet, which is equivalent to 141 pump horse-power. The engine first completed, which will hereafter be designated as Engine A, had a capacity in both steam cylinders of 177 cubic feet. The displacement volume of both steam pistons was 30 cubic feet per pump horse-power per minute. Similarly, the second engine, which will be designated as Engine B, had a combined steam cylinder capacity of 61 cubic feet, while its piston displacement per pump horse-power per minute was 15.7 cubic feet. It thus appears that Engine A was 2.9 times the size of Engine B in cylinder capacity, and was operated with 1.91 times its piston displacement per horse-power per minute.

It will be interesting to compare the performance of the two engines, both on duty trials and on regular service, for a period of fifteen years. Table I gives the results of the duty trials and yearly records of performance, as taken from official reports.

TABLE I.

	Engine A.	Engine B.
Volume of both cylinders	177 cu. ft.	61 cu. ft.
Piston speed per minute for capacity	187 ft.	252 ft.
Duty in pounds of water raised one foot per 100 pounds coal consumed on duty trial	93,000,000	103,900,000
Average duty on above basis for a period of fifteen years on all coal consumed	76,200,000	103,900,000
Total number of hours run in fifteen years	58,730	43,555
Total quantity of water pumped in fifteen years, reservoir measurement	13,002,936,110	8,921,818,259 U. S. gal.
Average gallons (U. S.) per hour	221,402	204,840

An inspection of the table shows that Engine B developed upward of 11 per cent. more duty on the official test, and 36 per cent. greater duty, as the average performance during fifteen years running, than Engine A, notwithstanding the fact that it ran fewer hours and consequently did less work, which was against its best economy. From this a fair deduction can be made that the small displacement volume per horse-power per minute in the steam cylinders of Engine B was conducive to economy of fuel. It should be stated that both Engines A and B were thoroughly steam jacketed on sides and ends and well built throughout.

An instance confirmatory of the deduction respecting economy in what has preceded will now be given: The city of Boston has, at its improved sewage pumping station, two compound pumping engines of a peculiar beam and fly-wheel type, one of which was tested in the spring of 1885 with the results given in Table II.

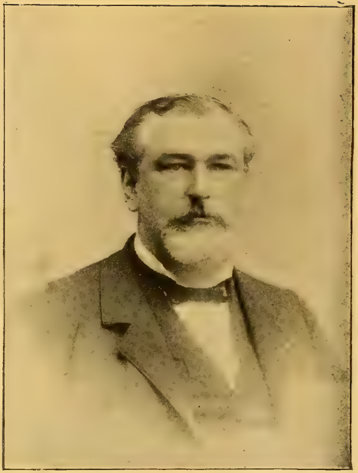
Engine B had a much higher efficiency in per cent. of the indicated horse-power, in work done in the pumps, due to its higher lifts, than did the Boston Improved Sewage Engine, which had, on the second test, an efficiency of but 83.9 per cent. On the basis of indicated horse-power, the volume of piston displacement per horse-power per minute is very nearly equal for Engine B and the Boston Improved Sewage Engine, when working at the maximum lift for which it was designed.

TABLE II.

	First Test, March 24 and 25.		Second Test, May 1 and 2.	
Duration of trial	24 hrs. 43 min.		2 hrs. 3½ min.	
Total revolutions	19,526		19,372	
Revolutions per minute	13.17		13.42	
Displacement of pumps per revolution	226.19	cu. ft.	226.19	cu. ft.
Total lift against pumps	37.8	ft.	42.43	ft.
Total pump displacement	33,038,000	gals.	32,778,000	gals.
Total coal consumed	8,307	lbs.	9,478	lbs.
Duty of engine as developed by the trials	122,500,000		122,400,000	
Indicated horse-power	251.5	H.P.	290.2	H.P.
Pump horse-power	212.9	H.P.	243.5	H.P.
Pump horse-power per cent. I.H.P.	84.66		83.9	
Coal burned per I.H.P. per hour	1.33	lbs.	1.35	lbs.
Water evaporated per pound of coal from and at 212°	12.12	lbs.	11.83	lbs.
Displacement volume of both steam cylinders per stroke	162.14		162,14	
Displacement volume of both steam cylinders per H.P. (pump) per minute	20.06		17.86	
Feed-water per I.H.P. per hour	13.898	lbs.	14.067	lbs.
Heat units per I.H.P. per hour	15,571.5	T.U.	15,427	T.U.

At the time the city of Boston received proposals for the improved sewage engines a prominent engine builder submitted a design embodying steam cylinders with but 42.36 cubic feet capacity, and a displacement volume of only 12.97 cubic feet per horse-power per minute. This design was rejected on account of the high speed of revolution required, viz.: thirty revolutions per minute, which was considered too high for pumps which had to contend with the impedimenta found in sewage. There can be scarcely a doubt, however, that a very high degree of economy would have resulted from the use of the small steam cylinders. It is also a matter ot record that this same design of engine has been for several years at work at the Providence water-works, developing a yearly duty of considerably above 100,000,000.

The city of Boston is having a triple expansion engine built at the present time in which the volume of the steam cylinders for 449 pump horse-power is but 69.6 cubic feet, and the piston displacement per actual horse-power per minute will be 15.5 cubic feet, being almost identical with that of Engine B, designed more than twenty years ago, and one of the first multi-cylinder engines built in the United States. The Allis engine at North Point Pumping Station, Milwaukee, recently tested by Prof. Carpenter of Cornell University, had steam cylinders with a combined volume of 233.55 cubic feet. It developed 521 pump horse-power at a speed 20.314 r. p. m., which gave a piston displacement per horse-power per minute of 16.3 cubic feet and adds valuable testimony to the accuracy of the deduction made in comparing the performance of the Engines A and B.



Chas. E. Emery
Decr 1st. 1893.

THE LESSONS OF THE COLUMBIAN YEAR.

By Chas. E. Emery, Ph. D.

Dr. Charles Edward Emery is widely known as one of America's foremost engineers, and has been prominently identified with a number of important engineering undertakings. He was born in 1838, served through the Civil War as one of the engineers of the navy, and subsequently was engaged in much engineering work of interest and value to the profession. One of his later achievements was the design and construction of the system of the New York Steam Company, by which the problem of supplying steam for heat and power purposes from central stations on a large scale through street mains was successfully solved. At present Dr. Emery is practicing as consulting engineer and patent expert.

THE success of the mechanical and constructive features of the Columbian Exposition were not so much due to the inventor, the artist or even the artisan as to that great leader in modern civilization, the engineer, whom we have previously identified as one who "harnesses the powers of Nature and guides them to and fro at will." Even Jackson Park, with buildings magnificent in size and appearance, in an artistic setting of large expanses of land and water, though requiring the grandest conceptions of those who with artistic tastes had made a life study of the architectural triumphs of the past, was made practicable only by the technical knowledge and skill of the engineer. The swampy flats which Chicago had commenced to reclaim quickly changed their character. The water was given definite bounds, the basins were walled, the lands raised and graded; anon the ghostly skeletons of great buildings arose, designed to imitate in architectural treatment those built in early historical times in enduring stone by millions of slave laborers during long years of toil. To attempt the real was prohibited by time and the enormous expense, notwithstanding the advances of modern improvements. The sham realistic was made possible by the knowledge of the engineer as to the strength of all parts of the flimsy frames which carried the so-called "staff" or clothing of the walls, and architectural features of the buildings. The engineer covered the domes and spans with modern structures of steel and iron, marvelous in strength and lightness, beautiful to the engineer because proportioned for the work, and appreciated by all from a feeling of fitness and security. Ornamental columns rose around the courts as beautiful in arrangement and proportions as those in the great colonnades and massive buildings of Rome when in its greatest glory, the magnificence of which in workmanship and selection of material can well be imagined by visiting various churches in Rome and vicinity.

Most of the engineering features incidental to the building of the great "White City" were carried out on a liberal and successful basis. Water for the imposing and attractive fountains was furnished by a large pumping plant erected in a special building by the Worthington Company, equal in size, appearance and efficiency to those which would have been furnished for a permanent city. The sewage was cared for on a well-designed application of the Shone system, so that by means of air pressure the sewage was forced to a special building and thoroughly treated to make the effluent to the Lake comparatively harmless. The lighting was carried out on a magnificent scale, under contract mostly with the Westinghouse Company, and the grounds and buildings were excellently illuminated both for safety and display purposes. The power furnished for the various branches of the Exposition was, probably for the first time in the history of such enterprises, designed and carried out on a scale sufficient for the purpose. The hotel facilities and transportation outside the grounds were amply provided for, and the latter was really quite efficient considering the temporary character of the work and the very considerable distances to be overcome. But the Illinois Central Railroad, after spending so much in raising its structure over the streets to the westward of the grounds and in clearing a route for special rapid transit tracks down to the city itself, could have well designed and constructed its excursion cars on the basis of its passenger equipment rather than that designed eventually for freight or cattle, as it was frequently expressed. The great lesson to be learned was the lack of proper transportation within the grounds. The electric launches and the few gondolas furnished pleasant excursions, and the rolling chairs were of assistance to the aged and weak; but these systems of high-priced transportation could hardly be considered in a great rectangle more than a mile square, with a T-extension nearly a mile long, with great buildings and features of interest distributed in all parts. True, an elevated electric railway skirted the grounds, but the lines of interior communication on foot compared so favorably with the distances out and back from this structure that it was far from furnishing what was manifestly necessary. Olmstead is reported to have said that if he had been asked he could have arranged the terraces so as to screen from direct view the sunken tracks of an electrically operated railroad which would have touched here and there the front of one and the rear or side of others of the principal buildings, but in the conception and early design of so magnificent a presentation no adequate thought could be had of how the masses were to be moved comfortably from one point to the other. This failure of satisfactory transportation is one of the great lessons of this international exposition which is almost certain to be properly provided for in the next.

Examining briefly in detail the various engineering exhibits, there were few that contained anything remarkably new in the sense of great originality. We fail to find the application of any new forces of nature or any of the older forces in a strictly novel way. That already known to be good was presented in various forms in a greater state of perfection and on a larger and more magnificent scale. There were novelties in the simple details of construction, involving no departures in principle, and there were special applications promising greater usefulness and general efficiency. We will discuss briefly a few of the exhibits and use the same as texts to suggest advances along the same lines independent of the Exposition.

The Transportation Department was particularly interesting in showing locomotives of large size which had been successfully developed for the various conditions of increased traffic, all emphasized by very striking comparisons with the many original types of so-called old locomotives which were constructed in the lifetime of many of us. The provisions for safety and convenience of modern travel in land conveyances of all kinds, in steamers for inland waters and in the great steamships which traverse the sea were all well represented, the lessons being that as the country advances in its manufacture of the materials of construction, and the engineers become better familiar with their use and have greater confidence in their reliability, such structures have been made larger, faster and, in a very important degree, safer than those constructed but a few years previously. The greater power has been obtained by the possibility of constructing marine boilers which would stand higher pressures and permit the use of economical triple compound engines which, by saving fuel, increase the capacity available to carry more powerful machinery.

The success obtained by the officers of the Navy Department in the design and construction of modern vessels of war, fully equal to those of the same class developed abroad and with greater speed, is a gratifying incident of this Columbian period. The high speed obtained by the new Columbia is of particular importance, as it demonstrates the possibility of dividing the power between three screws instead of two, not a novel idea strictly, but one not heretofore demonstrated on such a scale. All will recollect the recent transfer of two noble vessels from the English to the American merchant marine, and now the construction of two new ships is well progressed on this side of the ocean, which, although the first on such a scale, will unquestionably show that even the great setback received by shipbuilding in this country has been overcome, and America will, as far as speed and many other desirable features are concerned, take the lead in steamship construction. At the meeting of the recently organized Institute of Naval Architects and Marine Engineers the fact was developed that if the great depth of ships of the type of the Campania and Lucania be utilized as in a girder, to give the vessel longitudinal strength to resist bending moments, and the steam machinery be modeled more on the type of that used in our powerful war vessels than that thought necessary heretofore in merchant vessels, a power fully equal to that in the Campania and Lucania can be placed in a hull of less size and but little larger than that of the New York or Paris, and at the same time the ships be made stable without water ballast, whereas it is stated that some of the English designed ships have actually no metacentric height without such ballast being used as the vessels lighten. We are thus led to expect that the Cramps will show us features of safety, as well as of speed, which have not heretofore been attained.

The columns of CASSIER'S MAGAZINE have already pointed out the more prominent details of the great power plant of the Exposition. We will only attempt to record the impression that was made, in a general way, on one directly interested in such work. We refer first to the long row of boilers occupying a shed extending nearly the whole length of one side of the Palace of Mechanic Arts, and call attention to the fact that, with the exception of one exhibit, all of these boilers were of the water tubular, safety type, in which the water is contained in comparatively small cells with a large factor of safety. Of course, there were exhibited about the grounds boilers of other types, but they were mostly those of portable or semi-portable engines, modeled more or less after locomotive patterns. Is that great exhibit of boilers to indicate that the American people have progressed so far that they will think of safety independent of price in the generation of steam? The cost is a critical matter. It has been a revelation to find, from time to time, prices falling, till now the ordinary cylinder tubular boilers, with steel shells and best lap-welded tubes, can be bought, including fittings, for less than four cents per pound. The author has often pointed out that the question of boiler economy is an engineering one of proportion and rarely one of type (bad designs always being excluded), so that it is gratifying to find so many sectional boilers developed to practical success, which implies that the sales are on a scale sufficient to warrant the prosecution and extension of this important industry. The exclusive use in the Exposition of oil for fuel was a great convenience, and, whatever the cost, it was warranted by the omission of unsightly means of handling coal and ashes.

The steam engines at the Exposition showed clearly the types which have been found best adapted for particular kinds of service. The notable features were that many of the engines were of very much larger size than it has heretofore been thought advantageous to erect merely for exhibition during a limited period. The Allis quadruple-expansion engine of fully 2000 horse-power represented, probably, the extreme advance in the developement of the compound engine toward higher pressures and higher efficiency, but few appreciated this among so many other large engines similar in appearance. A cross-compound Allis-Corliss engine, also of 2000 horse-power, was in the Intramural Railway Station. The large number of Corliss engines made by different manufacturers was a silent tribute to the engineering skill and discernment of the great Corliss himself, and it is probable that this type will be a permanent one for engines of moderate speed, say 100 revolutions or under, although the speed of this type of engine is being constantly increased. It was pleasing also to see so many high speed engines by various makers, differing somewhat in the details of the valve gear and in the arrangement of parts, but all apparently operating well without the difficulties of heated bearings which used to be incident to this class of engine, and many of them regulating between no load and full load with an accuracy that is as surprising as it is gratifying. Vertical engines were well represented, particularly those adapted for direct connection to electric dynamos referred to hereafter. The English Willans engine is an interesting one of this type, shown only in small sizes, but tests have shown it to be very economical in fuel, for the reason that, simple as is its construction, it embodies the principles of the Cornish engine in transferring the steam from the surfaces upon which it has done its work to the other side of each piston, and the principle of the compound engine in dividing the temperatures and work up between different cylinders, thereby in a double way screening the surfaces from the cooling action of the condenser. A triple-compound engine of this type, of only 100 horse-power, is creditably reported to have given a horse-power for 15 pounds of water per hour. The only question is whether with so many packed joints the engine can remain efficient for long intervals in practice. A novelty of unproved utility was a Reynolds vertical trunk engine, with a valve rotated intermittently, step by step, by a ratchet. Steam was admitted only as the speed reduced, a method of regulation akin to that of gas engines.

In connection with this it is of interest to call attention to the fact that the consumption of steam in modern triple-compound engines has very nearly reached the limit assigned by theory. The firm of E. P. Allis & Co. must be credited with the greatest advance in this direction, which has been secured by rigid adherence to principles well understood—to wit, high steam pressure, reduced clearance spaces, steam-jacketed cylinders and a high degree of expansion. The lowest result yet recorded is 11.7 pounds of coal per indicated horse-power per hour, and there are a number of engines of this type that have given a horse-power for 12 pounds, so that this value may now be considered practically available under many conditions of practice.

It should be remembered, however, that the cost of coal is only one of the elements which enter into the total cost of steam power. The engines required to secure the remarkable economies stated are necessarily larger and more carefully constructed in detail, and therefore more expensive than engines which will give nearly as good results. The interest on the difference in cost may, therefore, be used fairly as an offset against the reduction in the cost of coal. Again, in some cases the repairs of the more expensive machinery are greater, and not infrequently a higher class of labor must be employed, thereby increasing the operating expenses. The evaporative power of the boilers of the more economical engine need not be as great as for the other, but the pressure is generally higher and details must be more carefully attended to, so that the cost in this respect would not vary greatly. Now, as the cost of steam power is represented by a summation of the costs of coal with all the other costs—and the latter will generally roughly equal the former for economical engines—it readily follows that if there is the least bit of extravagance in the cost of the finish or of the various appurtenances of the higher-priced engine, the gain due to the lower fuel consumption may be offset entirely by the increase in the auxiliary costs. These facts are important in the general consideration by the engineer of the adaptability of a particular engine for a particular work, but we are none the less gratified that such very desirable results have been obtained, not only for scientific reasons, but from the fact that it is pioneer work for the future. Coal now is very cheap, and will be probably for years to come. We must, however, consider that the cost of anthracite coal will gradually appreciate, and such fuel will be finally employed only for domestic uses, for the reason that the supply is limited. It has been estimated that if the present rate of consumption continues the anthracite mines will be exhausted in about 120 years. The development of the higher economies, even with increased costs for interest and incidentals, is also of great value in connection with mining interests in many locations where water power is not available and coal is very high-priced on account of transportation. In the English section a Galloway compound engine of fair size was exhibited, with the smaller cylinder arranged in an inclined position above the other, and both connected to the same crank, the air pump being horizontal and arranged behind the larger cylinder. While the engine was an excellent and reliable one, the greater feature of interest in connection therewith to an American was the example of power transmission with multiple hemp ropes. This system has never been much in favor in this country. The construction of leather belting has advanced here to an extent not known abroad, and has been accepted as the more satisfactory means of transmission. Walker, of Cleveland, is, however, recommending and largely introducing the system of rope transmission, of which notable examples are shown in the power-house of the Broadway Cable Railroad at New York. Another adaptation of rope-driving is shown in a power plant at Genesee Falls, Rochester, by Mr. Cartwright, in which a multi-grooved wheel on the turbine shaft, near the bottom of the fall, drives a similarly-grooved wheel on a line shaft, running along the bank above, by means of an endless rope running from one groove of the lower wheel over the upper pulley, back to the next groove in the lower wheel and to the next in the upper one a number of times, thus forming a spiral from which the outer parts connect through a weighted tightening pulley.

The display of pumps in operation at the Exposition, independent of those used for the fountains already referred to, was hardly equal to what has been done previously. The steam engines of high economy previously mentioned were, however, all designed for pumping water in water-works. Very many engines of this type have been made of special design, with the pumps in general directly connected to the pistons, rotary motion being secured sometimes by direct connection to cranks and at other times through beams of various designs. A feature of development since the Centennial Exposition is the attachment to direct-acting Worthington pumps of hydraulic rams, operating in connection with an accumulator to produce a high resistance at the beginning of the stroke, gradually reducing to zero at mid-stroke, which rams return the same amount of energy with gradually increasing intensity during the latter half of the stroke, thus permitting a high degree of expansion. In this way a very satisfactory economy has been obtained with a very simple form of apparatus.

There were more evidences at the Exposition of actual progress in the applications of electricity than in either of the mechanical departments. It is true that electricians criticised many of the exhibits in the Electric Building as mere "lamp shows," but the very effective arrangements adopted to decorate the building and incidentally to advertise the different systems were not only legitimate, but very attractive to the masses. To show features of electric lighting, the lights must be burned. As it was necessary that there be a regular system belonging to the Exposition authorities, to be depended upon under all circumstances, electric lights of different kinds were naturally exhibited, and in the end were so arranged as to make one exhibit as attractive as another. The success of the alternating system of electric lighting on the enormous scale installed by the Westinghouse Company was very gratifying. The generators were unusually large, each designed to furnish current for 10,000 lights. The current was generated at 2000 volts, and the lighting circuits were supplied through transformers. Each unit was in fact two generators, of which each part ordinarily operated on a separate circuit. The armature projections were, however, angularly set out of step, so to speak, with each other, so that the two parts of each unit could be used together to furnish current at "quarter phase," so-called, to operate electric motors through transformers. In a number of cases one of these double generators was directly connected to a Westinghouse compound engine of 1000 horse-power, run regularly at the extraordinary speed of 200 revolutions per minute. These engines differed from ordinary Westinghouse engines in being double acting, but the governor was enclosed in an oil case and the crank-pit was closed in tightly, the same as in Westinghouse engines of the ordinary type. The Westinghouse engine and generator practically formed one complete machine in itself. A number of these alternators were, however, used as loads for other engines in the Exposition.

There were a considerable number of combined engines and dynamos known as engine dynamos, some of them made up by mounting an armature directly on the shaft of a Corliss or other form of horizontal engine, and a number similarly mounted on the shafts of vertical engines. A very attractive engine of this type was shown by Schichau, of Germany, with a Siemens & Halske generator. The General Electric Company showed what is called an Edison engine, which is a vertical, triple-compound type, with the shaft extended in both directions through special bearings and carrying on each end an armature of an 800 kilowatt dynamo, the two dynamos being used together to furnish current at 150 volts on the Edison three-wire system. A 1500-kilowatt, 600-volt General Electric generator, the largest ever constructed, was mounted on the shaft of a 2000 horse-power compound Allis engine in the Intramural Station. There were several smaller direct-connected engine dynamos in that station, one of 750 kilowatts, operated by a Lake Erie vertical compound engine of somewhat less capacity than the generator. This engine dynamo operated the road for a large portion of the time and did excellent work, the engine being about the right size for the average load, and slowing when extreme loads were applied, thereby preventing such a large output of energy as would otherwise take place.

Both the Westinghouse and the General Electric Companies showed alternating systems for transmitting power. Electric motors were shown applied for all sorts of purposes where steam and other sources of power have heretofore been used, such as to the traveling cranes in Machinery Hall, various pumps, air compressors, portable cranes, railroad cars, elevators and numbers of smaller uses. A storage battery system was successfully operated in the electric launches which ran in the basins and canals, but perhaps the most striking application of electricity for power purposes was on the Intramural Railroad. In fact, the design throughout was worthy of study. The motors were placed in the trucks of a car to form a locomotive, located at the head of the train, and the weights were so distributed that it was possible to build a much lighter structure than is required for elevated railroads operated by steam. An ordinary wooden road-bed, carrying the rails, was supported on wooden posts and longitudinal iron beams. The current was transmitted to the cars from a third rail, located at one side, and was returned through the main rails. An electric air compressor was used on each train for operating the brakes. The system throughout was in every way successful and typified what can be done very readily in the streets of any city.

One of the curiosities of the Exposition, not yet tested by general use, was the Laval steam turbine in the Norway exhibit. With a turbine wheel only from four to five inches in diameter and half an inch thick, with the vanes occupying less than half an inch at the periphery, it was credibly reported that 20 horse-power had been obtained at a speed of about 30,000 revolutions per minute. This speed was reduced down by spiral gearing in order to operate the dynamo which furnished the load. At this speed the little wheel necessarily required the most accurate balancing, but, in addition, it was made with a very small spindle terminating in bearings of larger diameter, the effect being that any slight defect in producing an absolute running balance was corrected by the springing of the shaft, so that the wheel turned on its own centre of gravity instead of a mathematical axis through the bearings. This exhibit was notable on account of the use of an ordinary turbine. The Parsons and other steam turbines, so-called, depart very much in construction from the ordinary type.

There were plenty of exhibits which showed so much advance in skillful design and workmanship that they should be called novel. Weston's whole line of electrical measuring instruments, though founded on the D'Arsvonal galvanometer, are worked out so skillfully in detail, as the result of long-continued careful experiments, that in effect they become new devices which have proved of the greatest value to the profession. It is gratifying in connection with this to call attention to a real novelty. In the development of his instruments Weston discovered what had been desired for a long time—viz., a compound metal which did not change its resistance by change of temperature and which was capable of being formed into wire and used in the manufacture of his instruments. He also discovered what was somewhat more wonderful—viz., a metal compound which had a negative resistance co-efficient; that is, one of which the resistance decreases with an increase of temperature. The importance of these discoveries is thoroughly appreciated by scientific men in all parts of the world. Again, Dr. Gray's telautograph is a remarkable piece of mechanism, a pen at one end of a telegraph line reproducing writing and drawings, made with a stylus at the other end. The same motions had previously been made by adaptations of the Wheatstone bridge, but there was nothing positive about them. It was as if one attempted to write with one end of a straw by holding the other. So long as there was no resistance to motion the straw would correctly trace the character like the ink jet recorder of the Thompson cable registering apparatus, which is not practicable for ordinary use. Gray, with the exercise of great mechanical skill, combined a double "step by step" motion, one system right and left, the other up and down the paper, so that the motion of the hand, imparted to an instrument at one end of the line, is, by a series of minute steps, hardly noticeable in the writing, positively conveyed to the other, where the characters are produced with such fidelity that the handwriting is at once recognizable.

Electric heaters, which appear so simple, really contain some interesting features. In their construction wires, so small that they would be burned if exposed to the air when carrying the electric current employed, are embedded in materials which are non-conductors of electricity and which increase the radiating surface to such an extent that the small wires are kept below the temperature of fusion and the heat lost in overcoming the resistance of the wire is utilized either for cooking, warming rooms or other purposes.

There were hundreds of exhibits which deserve notice if time and space permitted this article to be more complete. In the vastness of Jackson Park no two persons saw the same things. If, therefore, this review reminds any one pleasantly of interesting objects, or calls attention to anything not observed or to any fact not known, the purpose of the writer will have been fulfilled.

Saml Webber.

Dec^{r}. 9/93.

THE DEVELOPMENT OF UNUSED WATER-POWERS.

By Samuel Webber, M. Am. Soc. M. E.

Mr. Webber is probably best known to most engineers through his extensive work in the line of hydraulic engineering, having largely devoted himself to that specialty for the last twenty years. His experience in allied branches, however, has been scarcely less thorough, and the seventy years of his life have been busily occupied in various fields of engineering.

TRIPHAMMER FALLS, NEAR ITHACA, N. Y.

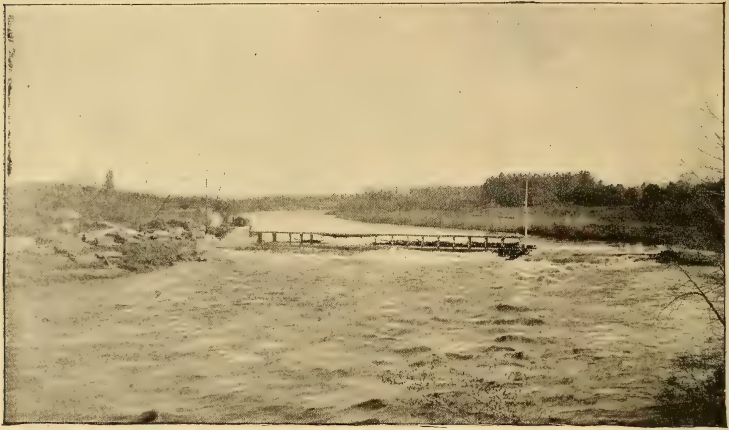
THE force of gravity, as shown in the fall of water from a high level to a lower one, was utilized at once by the first settlers of this country, not only, as in all primitive nations, for converting into meal the grains which were to supply them with food, but for providing the timbers and boards from which their dwellings were constructed, from the dense forests which originally covered the land, and which by the protection of their foliage rendered the water-power permanent and valuable.

In the latter respect, the condition of the country is sadly changed, for the destruction of the forests, though probably not affecting the annual rainfall to any material extent, has rendered the flow of the streams more variable, and more subject to heavy freshets in the spring and autumn, and equally severe droughts in the summer and winter. Notwithstanding this, there is a vast amount of energy, now wasted, contained in the annual flow of the rainfall from the mountains to the sea, and it is of the conversion of this to useful purposes that the author proposes to say a few words.

For the first hundred years of the settlement of the country, the aforesaid purposes were probably the only ones to which water-power was applied; but from the middle of the last century we begin to hear of its use for other purposes, such as the operation of trip hammers, oil-mills, and other machinery, and at the close of the century it began to be employed in the manufacture of textile fabrics, of cotton and wool, to clothe the citizens of the new and independent republic. The water-power of the country was more and more called upon to supply the forces which were needed to supplant human muscle, and the first great development of its employment on a large scale may be seen at the city of Lowell, in Massachusetts.

The preliminary experiment had been made on a moderate scale at Waltham, and the success of that led to the purchase of the water rights on the Merrimac river at Pawtucket Falls in Chelmsford. There a water-power plant of about 9000 horse-power was established, which has since grown to 19,000 available in times of flood-water, and the deficiency in low water is supplied by steam, of which there is now 10,000 horse-power in addition, so that Lowell uses about 30,000 horse-power all the time, varying according to the seasons, from 10,000 horse-power water, and 20,000 horse-power steam, to the opposite condition.

During the period from 1820 to 1830 nearly all the large water-rights in Massachusetts and New Hampshire and some in Maine were secured, and operations were commenced on the most eligible sites for building, but some valuable falls were left unused, for want of building room near by, and still remain unoccupied, although by the processes about to be described, they seem likely, before many years, to add to the sum total of the world's industries.



SEWALL'S FALLS IN THE MERRIMAC RIVER, NEAR CONCORD, N. H.—DAM IN COURSE OF CONSTRUCTION.

Such are Goff's Falls, on the Merrimac, between Nashua and Manchester, Garvin's Falls, between Concord and Manchester, and Sewall's Falls above Concord, and also the falls at "the Flume," on Salmon Falls river, a few miles above Somersworth, N. H., and one or two on the Cocheco river, all of which are now owned by some one of the large manufacturing companies. Besides these, there are numerous smaller water-falls, scattered all over the New England States, in situations more or less difficult of access, whose power seems destined, before many years, to be made valuable by means of electric transmission.

It is not likely that any of the larger ones first spoken of will ever be utilized as the site of manufacturing cities like Lowell and Manchester, for it has been found that coarse cottons can be made as well at the South, nearer the cotton field, as at the North, while the softer and more equable climate of southern Massachusetts and Rhode Island, along the shores of Buzzard and Mt. Hope bays, is so much better fitted for fine spinning than the more electrical atmosphere of interior New England, that the manufacture of finer fabrics is being established there. The low cost of freight for both cotton and coal compensates in some measure for the higher cost of steam power, which is to be used in those localities.

While I draw illustrations from New England, with which I am personally familiar, it must be understood that my remarks are equally applicable to the whole watershed of the great Appalachian mountain range. Here, as at the North, it will be seen that the large water-powers, like those at Augusta, Columbus and Columbia, are being taken up for the manufacture of cotton, which seems to be most successful when carried on upon a large scale, as skillful workpeople are thus concentrated, and more constant occupation is secured them. With the woolen manufacture it is very different. The much greater value of the "raw material" requires a much larger amount of "working capital" to handle it, hand labor forms a larger element in the production, and there is no class of woolen fabrics which çan be placed on the market and sold in bulk, of a uniform character, like sheetings and shirtings. The smaller woolen mills producing fabrics of a variable character have always been the most successful, and have been more widely scattered over the smaller water-powers of the Eastern and Middle States, and are now following the wool to the States in which it is produced in greatest quantities.

An examination of one of these small woolen mills, a few years since, to see if any change in their dam or water-wheels could be made which would enable them to increase their capacity about one-third, gives me a very pertinent illustration of my subject; for while I was able to suggest changes which, at the time, accomplished the desired end, the capacity of that fall was exhausted. Electricity, however, now offers a means by which, if necessary, the power of the mill could be quadrupled. The condition is this: The mill stands in a prosperous New Hampshire village on a stream, which, coming from a large lake, has a very steady flow, and furnishes at the mill about 100 horse-power. Between the lake and the head of this mill pond, a short four miles, there is a fall of over 300 feet, utilized only at one point, where another small woolen mill stands on a side hill, sufficient level ground being available to plant a mill, and make a very small pond. There is fall enough immediately below this mill, unused, to furnish 100 horse-power, and the same amount could be secured immediately above it, at the farthest point not two miles from the village.

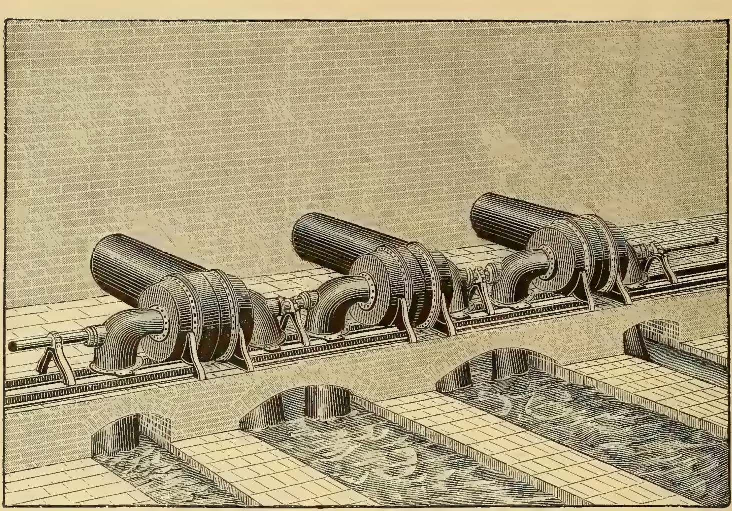
SEWALL'S FALLS DAM COMPLETED.

Then comes half a mile of level meadow, which could be dammed and make an admirable storage pond, and then a mile more of rapid current and small falls in the gorge below the lake, making 400 horse-power which could be developed at moderate cost, if a proper site could be found to use it. For such development, under such conditions, I should probably use a timber dam, such

TAUGHANNOCK FALLS, NEAR ITHACA, N. Y. HEIGHT, 215 FEET.

FLUME FALLS, NEAR ITHACA, N. Y.

THE GREAT SHOSHONE FALLS IN IDAHO. HEIGHT, 220 FEET.



RISDON TURBINES COUPLED TO A HORIZONTAL SHAFT.

as New England millwrights are used to building, and set a pair of small turbines on a horizontal shaft, as shown in the illustration on page 220, taken from a plant which I designed ten years ago. It does not show the whole fall, which was thirty-nine feet, thirteen feet of it being in the feeder, above the fore bay, in which the wheels were set, and twenty-six feet in the draft tube, below the wheels, this being about the extreme limit to which it is advisable to extend a draft-tube. A stand-pipe, not shown in the illustration, rose from the fore-bay, and the water in it always stood at the level of the head above the dam. Everything was timber except the wheels, quarter-turns, and draft tubes, which were of iron and air-tight.

A pair of turbines of from eighteen inches to twenty-five inches diameter, according to pattern, or maker, would give 100 horse-power under twenty-five feet head from the stream referred to, and make from 300 to 350 revolutions per minute according to diameter, and the total cost of such a plant may be taken at $5000, or $50 per horse-power, including dam. Now, if to this we add $30 per horse-power for generators or dynamos, at the wheels, $30 per horse-power for transmission wires, and $30 per horse-power for motors at the village, we have an investment of $140 per horse-power.

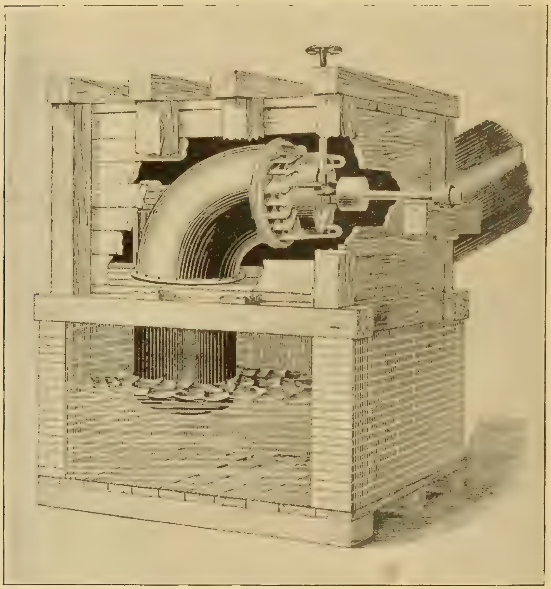
If we allow five per cent. interest on this plant, six per cent. for sinking fund, insurance and taxes, making $15.40 per annum per horse-power, and $450 per annum for attendance, we have a total of $1990, or say $20 per annum for the cost of one horse-power, or $2 per annum for the cost of an incandescent light, at the rate of ten lights per horse-power, and this is not over one-third the cost of steam-power, in similar small quantities, except when close to the coal mines. Similar conditions may be found all over the mountainous districts along the Appalachian range.

I have already spoken of the great undeveloped water powers on the Merrimac river, and I am indebted to my friend Mr. Geo. F. Page of Concord, N. H., the President of the Concord Land and Water-power Company, and the originator of the plan, for the following information concerning the operations now going on, to render this power available and valuable. The purchase of the water rights and 700 acres of land adjoining the falls, known as Sewall's Falls, has been quietly made during several years past, under the management of Mr. Page, with the intention of establishing a manufacturing town on the spot, where there are some admirable mill sites for building, but the recent improvements in electrical transmission of power have turned the thoughts of the projector to the supply of power to the city of Concord, where there are now some important industries. Mr. Page tells me that the height

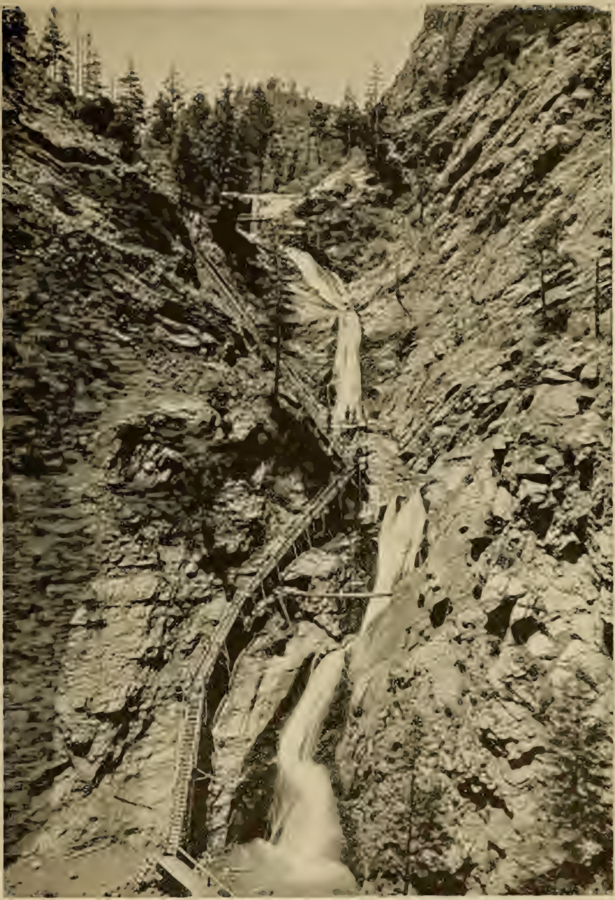
MULTNOMAH FALLS ON THE COLUMBIA RIVER, OREGON.

of the dam when fully completed, and the flash-boards on, will be twenty-two feet. The total horse-power given at the wheels will be an average of 6500, or about that. The total amount expected to be used in the city of Concord for lighting and power at an early date, is approximately 1000 horse-power. The distance of transmission from the falls to the State House is four miles, with service lines running in some cases two miles further. The cost of generators at the dams, transmission wires, and motors in the city of Concord is estimated at $30,000 for each, or $90,000, for 1000 horse-power. He adds: ''We are going to introduce here what is known as the three-phase or 'triphase' system for power transmission, a voltage of 2500, transmitted over small wires, at small drop, and so arranged that the same currents, where we desire to do it, can be used for power, incandescent lighting, and for arc lights also.''

The dam was constructed by W. H. Ward, contractor, of Lowell, Mass., and the power house is being constructed by H. E. Fletcher, of Lowell. The head gates were constructed by Mr. Ward, and the water-wheels are put in by the Rodney Hunt Company, of Orange, Mass., who also furnish the feeders and draft tubes. The wheels are in five pairs, each pair capable of producing 400 horse-power. They are of the horizontal type. The belt pullies run in pans, or tanks, and the house is so constructed with a pump, that the water, in case of a flood, is not expected to get inside of the wheel-house sufficiently to cause damage to the belts, even if there were no pans, but the latter are a special protection against wetting the



A SINGLE RISDON TURBINE ON A HORIZONTAL SHAFT.



SEVEN FALLS, CHEYENNE CAÑON, NEAR COLORADO SPRINGS, COL.

belts. The power house is 150 feet in length by forty feet in width, on a solid masonry foundation. The power is to be regulated by a Schenck electric governor, and the whole electrical apparatus is furnished by the General Electric Company, while the shafting and pullies are made by the Kidder Machine Company, of Franklin, N. H. A canal sixty feet wide, and of ample depth, is provided to supply power to such manufacturing establishments as may prefer to locate near the dam and use water direct. The power house is so built as to be capable of extension, if needed, so as to add more turbines and generators.

The generally adopted plan of setting turbines for such purposes is shown in the illustration on page 218, which

LUCIFER FALLS, ENFIELD GLEN, ITHACA, N. Y.

represents three pair of turbines, on one shaft, giving 2000 horse-power under a forty-nine foot head, and was planned by the advice of the late Jas. B. Francis, of Lowell, so as to use a variable quantity of water to the greatest economy at all times. Although these wheels were from another builder, the general form of setting them on horizontal shafts, adopted by all builders, is so similar that they serve very well to illustrate the plan here in question.

Mr. Page also informs me that the Concord Land and Water-power Company has obtained a control of Garvin's Falls, two and one-half miles below Concord, so far as electrical currents in Concord are concerned, for fifty years. It has also purchased the Concord Gaslight Company's electrical plant, this corporation agreeing to do no business in Concord in electricity during the next fifty years. A large number of incandescent lights are being put into dwellings, public buildings and stores, and the company has a large and rapidly growing trade in power and lighting, both by arc and incandescent lamps, and is also beginning to receive orders for heating and cooking.

The writer had a long correspondence with the late Prof. M. G. Farmer, on the subject of transferring the power of Garvin's Falls to Manchester, for use in the mills, about a dozen years ago, but the utmost which could then be guaranteed was sixty per cent., and the cost of transferring it over the distance of twelve miles was so great, that the project was abandoned as impracticable. The power which may be obtained there is not far different from that at Sewall's Falls, or about 6500 horse-power, and it will probably be partially utilized on the spot for paper manufacture, as the Amoskeag Company, who have maintained an unused dam there for many years, have recently sold the property to some men who are largely engaged in that business. I have dwelt somewhat at length on this project, as it is now actually going into operation, and although not on so large a scale as the great scheme at Niagara Falls, is still of sufficient magnitude to warrant calling public attention to it. I might also mention the operations of the Lewiston Electric Light Company, of Lewiston, Me., who have had a twenty-six foot dam built on an unused fall on the Little Androscoggin river, about two miles above Auburn, and put in a pair of wheels intended to give 500 horse-power, placing in their power house generators to run 4250 incandescent lights in the cities of Auburn and Lewiston.

THE YOSEMITE FALLS, CAL. HEIGHT, 2600 FEET.

I have said enough on the details of this subject; there are no doubt many other enterprises of the kind in progress, of which I have no positive information, but my aim has been to draw attention to the practicabilities and probabilities of the future. I might go still further, and say that there are now

BEAR CREEK FALLS, COLORADO.

many water-falls which form a delightful attraction to places of summer resort, which, after having added to the beauty of the scenery by day, might also be made valuable at night, by turning the water into a turbine feeder, at dark, and furnish electric light in the evening and night, for the summer hotels and village streets.

F. R. Hutton
December 8th 1893.

A RELATION OF ENGINEERING TO PROGRESS AND CIVILIZATION.

By Professor F. R. Hutton, C. E., Ph. D.

Graduated from the Columbia School of Mines in 1876, Professor Hutton successively occupied the offices of instructor and adjunct professor in mechanical engineering there, and in 1891 reached the full professorship. In 1883 he was elected to the secretaryship of the American Society of Mechanical Engineers, which office he now holds in addition to his other professional positions.

AN element which doubtless added much to the enjoyment of every visitor to the the Columbian Exposition was the faultless critical faculty by which the governing authorities were guided in their selections. In no other respect was this more manifest than in the choice of him who was to present suggestive and appropriate mottoes to be worked into the the decoration of the buildings. It would, perhaps, be an unnecessary inviting of controversy to say that engineers in particular visiting the Fair were impressed with those chosen for the Transportation building. But it may be remarked that by the use of sentences from writers who lived sufficiently in advance of this century of progress it has been brought out that their intuitive perceptions of great truths amount to a prophetic forecast. One of the many definitions of genius is that it is a power to see and record truths which every one knows but has not been able to announce, but in the case of Lord Bacon and the quotation credited to him, the achievement rises further and higher than this, when account is taken of the conditions prevailing when it was uttered. The quotation which the writer seeks thus to commend, and whose full import is not appreciated by the great mass of the general public, is in these words: "There are three things which make a nation great and prosperous; a fertile soil, busy workshops, and easy conveyance for men and goods from place to place." If it be true that the relations of engineering to the greatness of a nation are even to-day not generally realized, the light from this solitary seer in the past gleams out upon the student so much the more brilliantly.

Bacon was a philosopher of the Elizabethan period of England, his active service running forward into the beginning of the reign of the first James of the house of Stuart. At the end of the sixteenth and the beginning of the seventeenth centuries Leeds, Manchester, Birmingham and the other industrial centres of England were but modest towns, distinctly provincial, and without noteworthy influence upon the national life. The profession of arms was the road to honor and preferment, the crusades themselves were not so far in the past, and the Reformation was but a hundred years in perspective. The puddling of wrought iron was many years below the horizon, while the Marquis of Worcester, with his "Century of Inventions," and Papin, with his digester and safety valve, belong in the latter part of this same seventeenth century. The whole industrial system, so far as it existed at all, was based on the principle of individual labor by a master workman, whose shop was in his own house and whose apprentices were members of his household. Beside those mechanic arts attaching themselves to the needs of the warrior and the husbandman, the weaver at his own home was by far the most important, and special emphasis had been given to this craft by the escape into England of so many of the industrious and conscientious Huguenots, expelled from France by the revocation by Henry of the Edict of Nantes. When Bacon, therefore, speaks of "busy workshops," to him they mean the individual establishment of the craftsman, and not the busy hive where the labor of many hands was concentrated under one management in what we of to-day call a factory or a workshop.

But this only adds to the wonder that in his outlook upon the conditions which make a land great and prosperous, the philosopher should have generalized from small to great, so that his clear vision should have been able to appreciate and his analytical mind to formulate the relation which engineering in its modern sense has borne and now bears to national progress, and is likely to bear even more and more as the forces of nature are made by the engineer more and more the servitors of man.

In the rise and progress of a nation, whether it originate in a virgin land by colonization or by conquest, it will be a matter of the most immediate and vital consequence that the soil of the new land be a fertile one. The husbandman will be the first laborer in demand, because the pioneers of the infant colony or the struggling settlement, with its women and children, must be fed. The craft of the hunter also in a new country, and of the fisherman, will be of great moment in conjunction with that of the farmer. It is apparent, however, that if growth and development stop here the community will be a small one, with limited demands and probably limited achievement of any sort. It will remain a hamlet merely, and is not likely to grow to a centre of intellectual or other activity.

The reason for this is not far to seek. In the nature of the case, a purely agricultural country to be successful must not be too densely populated to the unit of area, since for economical husbandry, as in manufactures, the secret is a large output, with a comparatively small outlay for labor. This means, therefore, large farms with a comparatively small number of persons living on them, whereby the farmsteads become necessarily remote from each other. There will be a central settlement, where the blacksmith and the house-builder, and the tailor and the storekeeper will have their abodes ; but the idea of the city is impossible under these conditions.

By natural increase, however, and a probable influx by emigration, a greater number of men forms a part of the little community, and they cannot be aught but bread-winners. The farm does not want them, and labor must be found for them in some other department of industry. The large farm, moreover, with a fertile land, produces more than those living on it will consume, and if the prices of their commodities are not to fall unduly, a demand must be created in their neighborhood. This concurrence of a supply and a demand in a settlement of this sort results in the beginning of manufactures, and the "busy workshop" springs up—first, in the segregated units of the earlier day, and later, by the aggregation of many workers in one great establishment. The necessity for the support and the supply of the needs of this workshop or factory population, which will now become very dense per unit of area for the best conditions, will attract the exchangers of commodities. Stores must be provided, which again call for a class of laborer who will live densely over the area which he serves. The result of these two forces will be the city. It is a platitude of the inspection of recent census reports that the development of the modern State shows an enormous increase in the sizes of the cities. We have here in the foregoing considerations, apart from any questions of sentiment or choice or selection, the reasons which in a prosperous nation point to this very result. It is also an interesting question which, although aside from the direct matter under consideration, is at once suggested at this stage, and that is, that the consolidation of manufacturing interests, which is a feature of the industrial life of to-day, is just as unmistakeable a mark of progress for the country at large in the direction of the cheapening of manufacture as the consolidation of the segregated workers into the aggregate of a factory has resulted in a noteworthy cheapening of product, while the compensation of the laborer is even greater in proportion than under the old conditions. The period of transition from the one system to the other is the period of hardship. It is also suggested here to the thoughtful that that national policy which encourages the development of manufactures within the nation and builds up the busy workshops of the philosopher is the one which develops the cities, which, with all their dangers, are yet the centres of intellectual and spiritual force in the nations of the earth.

The thinker must supply for himself the function which the engineer has exerted in the development of the factory and the city which is its consequence. The busy workshop of to-day is nought else but a series of creations of the busy brain of him who applies the force of heat or gravity to the turning of the hundreds of whirling wheels and who has transmitted and converted the motion thus made available for the myriad purposes which his brain has planned.

But the Philosopher saw further than this. He saw that a great and prosperous nation could not be a nation brought up without homes, or whose homes were not comfortable and happy and sunny. Knowing well his countrymen and the deep-rooted instincts of the Anglo-Saxon race, he knew that he would not be permanently contented when his home life also was conducted in an aggregation of families under one roof. He may not have foreseen the tenement house, but he knew what it meant for the worker to come refreshed each morning to his toil from the independence and the dignity which surround him who is at the head of his own private house. He foresaw also that the history of the husbandman would repeat itself for the manufacturer, and that he would produce more product than could be economically disposed of in the city of its origin. He said, therefore, that a third element was necessary to secure the greatness of his prosperous people. They might be prosperous with the other two, but they would not be great. That third element for this greatness and prosperity is "easy conveyance of men and goods from place to place."

For men this easy transportation means suburban homes, outside of the restricted area of the industrial or commercial cities ; it means, for another class, the culture and intellectual stimulus which come from travel and new scenes. For goods, it means a whole country for a market, perhaps the world ; it means a lowering of barriers for commercial intercourse ; it means a reduced cost of manufactured articles to the community as a whole, so that if wages are not lowered at the same time, there is a larger balance which passes to the community to expend for those elements which go to uplift it and to move it upon a higher plane. The artist, the historian, the writer, the student are all the products of this latter phase of a nation's rise.

As before, it were idle to point out the relation of the engineer to this feature of development. The civil engineer lays out roads, canals and the railroad ; the mechanical engineer applies his motive power by water and by rail, and men and goods are conveyed with increasing celerity and certainty between their objective points. If the flying machine is to make communication as free as air it will be by the engineer that its work will be done.

It is unfortunate for the engineer that his work, fundamental to so much which makes the comfort and civilization of the day, should be concealed and disregarded simply because it underlies. Without the engineer, life in cities would be impossible, where there was no gas, no water supply, no sewage, no food supply except by wagons, no motive power but human muscles. There would be a patrician class served by a class of slaves, and that great, powerful, conscientious, reliable middle class which makes a nation great and prosperous would be unknown.

Even in the Columbian Exposition, which has been considered the flower and example of what this century has done in the way of artistic culture and industrial progress, beneath the architectural beauty and genius of conception there lies concealed and embedded many weary months of a burning of midnight oil and of the expert skill of the engineering toiler in the preparation of the ground and the erection of the structures. Those who delighted in the luminous fountains and the marvelous effect of electric illuminations and the ghost-like flitting of the launches on the lagoons by night, gave probably hardly a thought to the pulsing pumping engine and to the whirring dynamo over whose production the engineer had presided and over whose regular march a faithful, conscientious but unseen toiler was watching with a ceaseless attention, and he also an engineer. So, then, these "things make a nation great and prosperous: a fertile land, busy workshops, and easy conveyance of men and goods from place to place."

William. M. Henderson.

December 3, 1893.

THE PALACE OF MECHANIC ARTS AT THE WORLD'S COLUMBIAN EXPOSITION.

FOUR DISTINGUISHED NAMES.

By Wm. M. Henderson, M. E.

William Murray Henderson was born in Edinburgh, Scotland, in 1831. He was one of the Government engineers in Chili for 3 years, and was subsequently engaged for several years in railroad building in Peru, Venezuela, and Mexico. He was also the designer of the first Cornish beam engine built in the United States, erected at the Spring Garden Water-works, Philadelphia, about 1854.

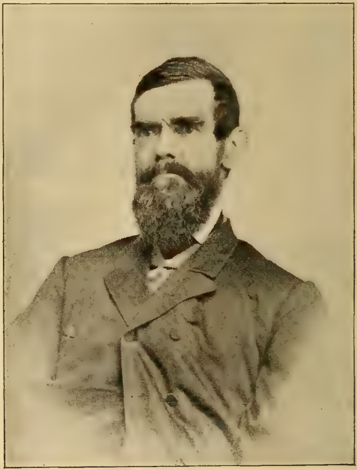
HOLLEY, Trautwine, Eads, Newton. These are the names that graced the entablature on the east façade of the southern aisle of the Palace of Mechanic Arts at the World's Columbian Exposition.

John Cresson Trautwine, James Buchanan Eads, John Newton and Alexander Lyman Holley were born respectively in 1810, in 1820, in 1823 and in 1832. Trautwine died in 1883, aged seventy-three years; Eads, in 1887, aged sixty-seven years; and Holley, in 1882, aged fifty years. General Newton today presides over the fortunes of the Panama railroad, which Trautwine located in 1850. Trautwine, Eads and Newton may be taken as representing what has come to be called the "civil" branch of engineering. The term "civil" was originally used to distinguish the non-military from the military engineer, but now that various subordinate branches, as the mechanical, the mining, the electrical, have become differentiated from the profession of civil or non-military engineering, the application of the term "civil" has become popularly restricted to those branches which as yet have hardly attained to the dignity of separate professions, such as bridge, railroad, canal and water-works engineering. And so Trautwine, with his railroad work, extending back almost to the nativity of the American railroad system and including the Panama railroad, with his Atrato survey for an inter-oceanic ship-canal, and with his Civil Engineer's Pocket Book, which, to-day as ever, is "the engineer's Bible;" Eads, with his great works, the St. Louis bridge, the South Pass jetties and the projected Tehuantepec ship railway; and Newton, whose name will ever be associated with the removal of the rocky barriers of New York harbor, stand out as among the most prominent of American civil engineers.

A L Holley

Holley, on the other hand, was preeminently a "mechanical" engineer. Beginning his career on the foot-board of a locomotive, he soon became one of our foremost authorities upon locomotive construction and operation. Later, becoming interested in the manufacture of Bessemer and open-hearth steel, he rapidly achieved, in this line, a distinction perhaps quite as marked as that which crowned his labors in the field of locomotive engineering. In the words of Abram S. Hewitt, uttered at the Holley Memorial Session of the American Institute of Mining Engineers, held at Washington on February 22, 1882, Holley was "a mechanical engineer of unerring judgment, an inventor of the true means for great results, a lover of his race who subjected his science, his talents and his labor to the good of his fellow-men."

Of the four men here named, General Newton is the only one who can be said to have added the laurels of the soldier to those of the engineer. As an officer of the U. S. Army he took part throughout in the War of the Rebellion, during which he was twice brevetted for gallantry. It was the writer's good fortune to enjoy the friendship of the three departed members of this illustrious group, a friendship which gave him opportunities of becoming



John C. Trautwine.

ENTABLATURE WITH NAMES ON THE PALACE OF MECHANIC ARTS.

acquainted with their individual characteristics, apart from their professional achievements. It is therefore with a sad pleasure that he endeavors to place before the reader something of the personal side of these men. Here we find the name of Holley standing out in bold relief. This great man, with all his brilliant accomplishments as an engineer, shone almost more conspicuously by reason of his personal characteristics. His genial nature won for him at once the friendship of those who were fortunate enough to come in contact with him. Great of head, he was, if possible, even greater in heart. Kindly toward all, ever ready to sympathize and to aid, with a smile for everyone, with a ready wit and a most attractive personality, he was the idol of the very large circle of friends in which he moved.

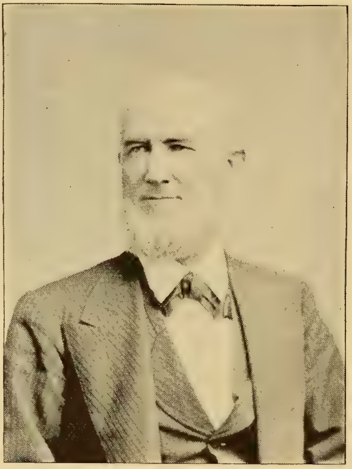
"His friendship, once given, never faltered. Probably no one had his good offices worse abused; but he never soured, and ever had an excuse for the delinquent."

"He was a gatherer and a scatterer. He gathered items and gave whole systems in return. He gathered flowers from every place, but handed to his friends bouquets of knowledge and artistic plants of rare beauty. He gathered for himself a few thousands, and scattered to his clients and friends throughout the world untold millions. He gathered all hearts into his own large heart, which shed its overflowing love on everyone he met."

"He was so much to us; we miss

him so sorely! A meeting, and no paper from Holley; a banquet, and no speech from Holley; a cordial reunion of fraternal joy and no smile or handclasp from Holley; it is more than sad, it is bewildering." So it was that this man's friends spoke of him.

Trautwine, the "dear old veteran," as his friend Professor Vose loved to call him, although perhaps no less warmly loved, no less sincerely admired by the few who knew him well, was debarred from attaining the wide popularity of Holley, partly by his diffidence, which absolutely prevented him from speaking in public; partly, it may be, by a combination of an almost pugnacious integrity with a streak of acidity in his nature which could as readily antagonize as his genuine goodness could attract. Thoroughly true and kindly in himself, he would fain have believed all others equally so, and the cruel disappointments which undeceived him in this respect ruffled at least the surface of the deep and otherwise smooth current of his life. And this unhappy result was aggravated by constitutional derangement of the digestive organs, and, in his later years, by extreme nervous prostration, the result of over-work and of the fevers contracted in tropical countries. Personally, this eminent Philadelphian was one of those quaint appearances that are apt to repel the chance acquaintance, but which charm by their very oddity and homeliness the closer friend. Of medium height, unusually long in the trunk, as rigidly upright in body as in life, his dress of the plainest, culminating usually in a dingy stovepipe hat which accentuated his extreme perpendicularity and crowned a homely and deeply-furrowed face, carrying a pair of bushy eyebrows, and set in a frame of uncompromising and grizzly hair and beard, his empty right sleeve pinned squarely across his breast, and his glove carried loosely in his left hand; his odd figure became so well known an object that the newsboys on Chestnut street have been known to offer him unsolicited credit.



Jas. B. Eads

Of Eads, who was the first American to receive the Albert medal of the British Society for the Encouragement of Art, we learn chiefly through his existing works. In these we read of singleness of purpose, originality and breadth of view, activity and elasticity of intellect, fertility of resource and a commanding will. But to those who knew him well he was endeared by the same generous spirit that characterized the two kindly natures we have just studied. His friend and associate, Mr. Elmer L. Corthell, says of him: "He was generous to a fault, and no one ever went away from him empty-handed."

J. Wendell Cole
Dec'r 6/93 –

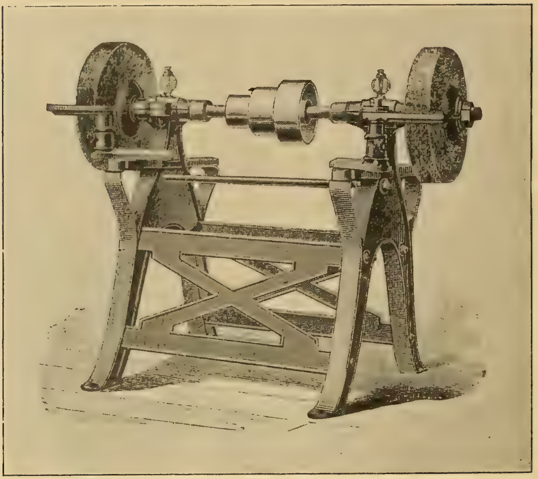
EMERY WHEELS AND SOME OF THEIR USES.

By J. Wendell Cole, M. Am. Soc. M. E.

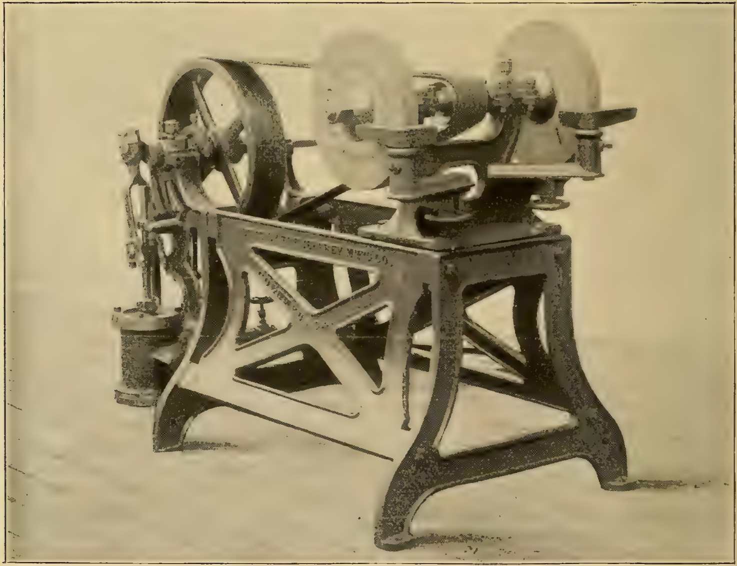
Since 1878 Mr. Cole has been district manager at Columbus, Ohio, for the Detroit Emery Wheel Company, having previously been connected with the Novelty Iron Works, at New York, the Hoosac Tunnel and various other engineering firms and enterprises. He was born in 1842.

THE general title emery wheels includes polishing wheels and solid emery wheels. Polishing wheels are made of wood covered with a leather band or belt, and the grain emery is glued on the surface. They are also made of walrus hide, paper, solid leather, canvas and felt. Grain corundum, too, is used to some extent on polishing wheels, but, to get the best results, is used finer than the emery that would be selected for the same purpose, as the corundum, while harder, is more brittle and apt to crush more easily under pressure than emery. "Solid wheels" include generally emery wheels, emery corundum wheels, and corundum wheels, and are a compound of grain emery and corundum, cemented into a wheel that is sharp at the circumference, and continues a cutting wheel until worn down to the collars, while polishing wheels soon wear off the coating of emery and must be recoated.

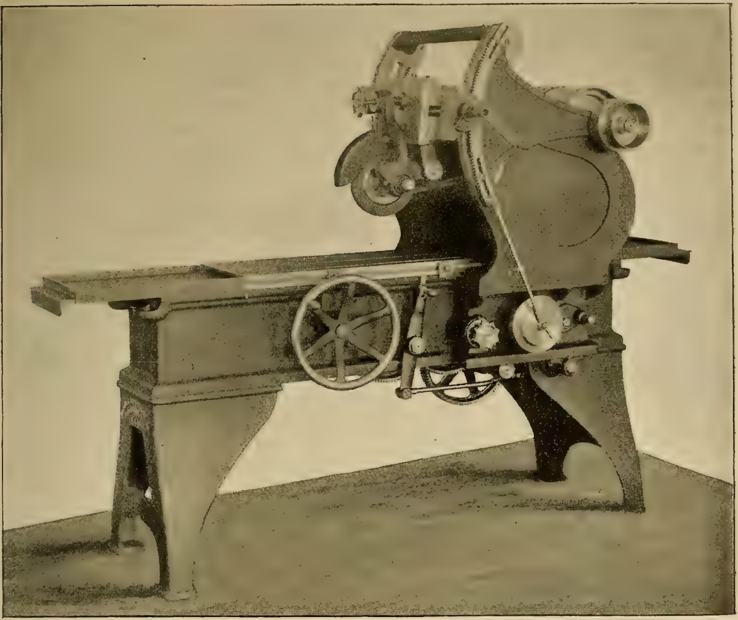
The distinctive feature of the various makes of solid emery wheels is in the kind and quality of the cement used. They may be divided into first, wheels in which are used gums like rubber and shellac; second, those cemented under hydraulic pressure and dried and seasoned, like the Northampton and Tanite wheels; third, wheels made by pressure and molding, and cured by heat like the Hart or Detroit wheels; and fourth, the several vitrified makes, in which a flux is melted into a cement. No one kind of wheel is the best for every kind of work. The rubber cement has to be softened and melted by frictional heat before the emery will cut without glazing, and this takes much extra power. Other cements are not good conductors of heat, and cause the surface of the wheel, if used dry, to flake out or "spall" off. Vitrified wheels have to be watched carefully, as they are of a brittle, glassy nature, easily cracked by a blow. In fact, emery wheels are like steam boilers—very useful, but must be in good condition to stand the strain, and should have intelligent care with frequent inspection. They should also be kept round, as, if out of round, they cut only on the high side and thus waste the time of the workman, and also are worn into cams and strike a dangerous blow. The best cement is one that binds the emery together with sufficient strength to resist the centrifugal strain due to the high speed at which emery wheels cut best, about 5000 feet surface speed per minute. It must not soften by frictional heat, nor glaze, nor burst, nor become brittle and break with cold. It must not hold the cutting grains until they are too dull to cut; nor release them so readily as to waste away the wheel too fast. It must be capable of being thoroughly mixed evenly with the grain emery, so that the wheel may not have either hard or soft spots, and be out of balance, and it must also be



A SIMPLE DETROIT EMERY GRINDER.



EMERY GRINDER WITH SPECIAL DRIVING ENGINE.



A BROWN & SHARPE SURFACE GRINDER.

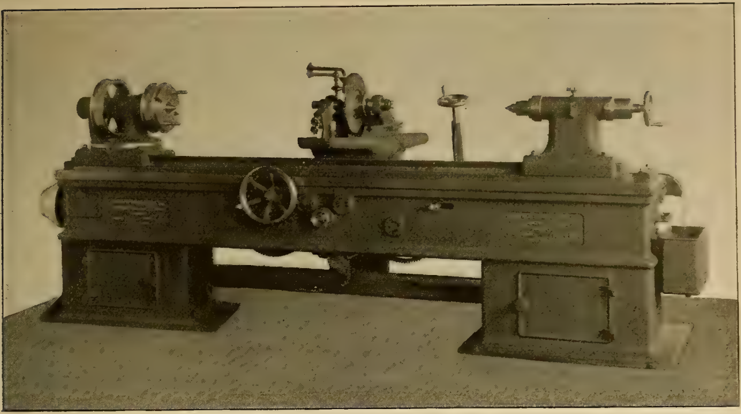
capable of being tempered to suit different kinds of metal or work. As great care and skill is required to select and use only pure and strong chemicals in these cements, and as careful, skilled workmen are necessary to manipulate and use them aright, one runs great risks in buying wheels to try from any but well-known, experienced and thoroughly responsible makers.

The work for which solid wheels are used can be divided into five classes :— First : The grinding-off and smoothing of gates, sprues, fins and lumps on castings of iron, steel and brass. A good example of a strong well-designed machine for such work is the grinder, illustrated on page 240. The requirements for such work are a well-braced, heavy frame, stiff rests, a large arbor with long journal bearings, large diameter of arbor and countershaft cones, and a broad belt. The arbor is set on the apex of the "A" frame. With such a combination the wheel runs steady, and cannot be slowed down. Slowing down the wheel, when under heavy pressure of work, loosens and pulls out grains of emery, thus making spots and unbalancing the wheel. When it is inconvenient to get power to the grinder in ordinary ways, a machine made by the Jeffrey Manufacturing Company, and shown on page 240, can be used by piping steam or compressed air for power, the engine and wheel arbor being combined on one frame.

Second : Filing and fitting, as in general hardware, stoves, plows and agricultural machinery. Where a skilled workman is permitted to keep a wheel for his own use true for accurate filing, a great amount of vice work can be roughed out and rapidly filed on the solid wheel. This branch of emery wheel filing is as yet but partially developed. Too often every unskilled boy or helper is allowed to run to the nearest wheel to cut down a bolt end or sprue, and thus quickly misuse and spoil a wheel for vice work by scoring grooves in its surface, or by rounding its corners. It would be as good judgment to allow "Tom, Dick and Harry" the run of the brass files and the smooth files in the best vice hand's "kit." Such trouble can be avoided by using a protecting table on wheels used for surfacing, a simple form being shown on the opposite page.

Third: Surface grinding, in which the object is to remove metal and leave a flat surface. A good example of machine designed for this kind of work is the Brown & Sharpe Manufacturing Company's No. 3 surface grinder, shown on page 241. One considerable drawback in such work, is that if any cut but the very lightest is taken, one surface of the metal is unduly expanded and the surface true on the planer becomes hollowed when the metal resumes its normal temperature. On an emery wheel planer at the Don Locomotive Works at Glasgow (1875), the metal was held in a water pan on the planer bed, thus absorbing the heat and equalizing the temperature; but such a method is at times too sloppy to be convenient. In agricultural machinery and other shops it frequently occurs that with metal patterns, castings can be made so accurately that on some pieces very little tool work besides drilling is needed, and the slight differ-

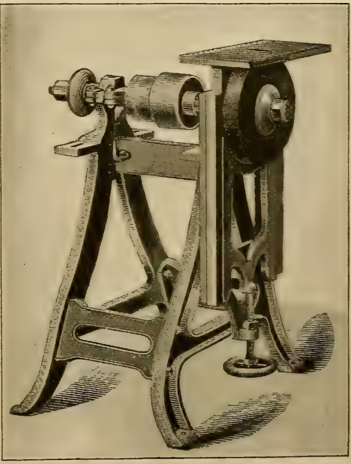
DRILL GRINDING MACHINE, WITH DRILL POINTING ATTACHMENT.



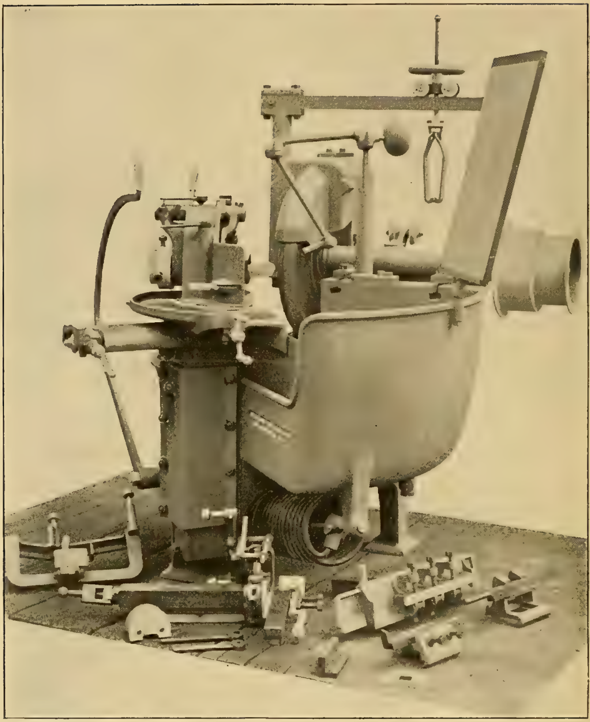
A UNIVERSAL GRINDING MACHINE.

ence in castings arising from the spring of patterns or from rapping them can be accurately ground off by having metal chucks, or wooden chucks, or clamps, metal-faced, on bearing slides, where many of one pattern are handled, one clamp for each pattern. Then the bearing slides on the machine being parallel with the sides of the wheel and adjustable in height, and the bearing slides on the clamp being at right angles with those on the machine, an ordinary straight faced wheel can be used to face all surfaces on the casting. Mr. Joseph Dick of Canton, Ohio, is doing accurate work by very ingenious combinations of such clamps that he has designed for portions of his castings. These clamps can be best designed in each shop to meet its own requirements.

Fourth: Cylindrical grinding in which both the work and the emery wheel are revolved in a grinding lathe. The using of high speed machinery and the demand for greater accuracy in machine construction call for machines better adapted to produce uniform surfaces and accurate work than the lathe and the planer of the past. It is well known to all engaged in the manufacture of tools of precison that the lathe is incapable of producing accurate work, even in the softer metals, and upon hardened surfaces steel tools fail altogether. Journals and other wearing surfaces should be true and smooth when made. The success of high speed machinery depends upon accuracy. The

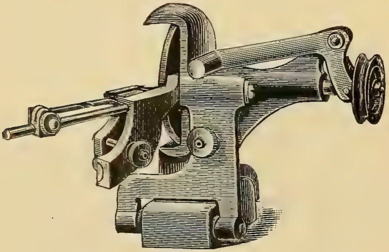


EMERY GRINDER WITH PROTECTING TABLE.



THE SELLERS TOOL GRINDING MACHINE.

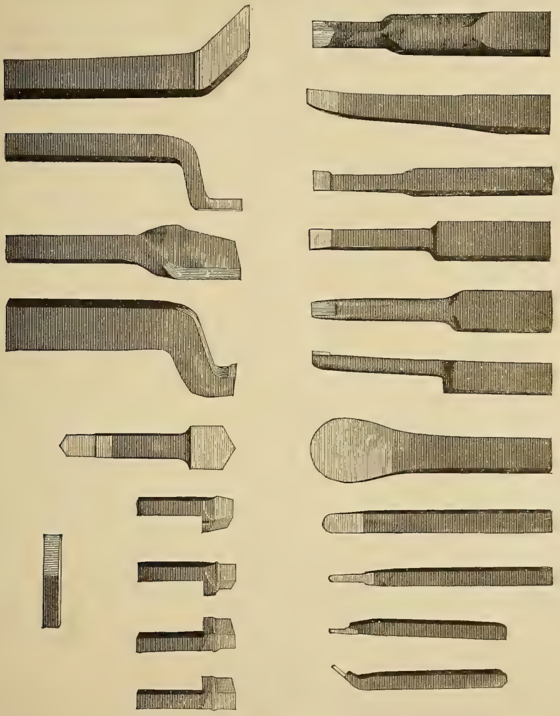
best method of securing so desirable a result is to turn, on a good lathe, as true as possible; then finish by grinding on a suitably designed machine. One of these is shown on page 243 and is designed by the Brown & Sharpe Manufacturing Company. The most accurate light lathe work, such as sewing machine spindles, etc., is now largely finished by grinding wheels; also steel and chilled-iron plate rolls, rolls for paper calendar machines and for a variety of other uses. Chilled car wheels, cast in automatic shrinking chills, are ground to remove the fins from the tread; also when flattened to restore them to circles, and some new ones, if cast slightly out of round, are ground up true. Locomotive drivers,



A DRILL POINTING ATTACHMENT FOR AN EMERY GRINDER.

when slightly flattened by service, can be rounded up by grinding.

Fifth: Tool grinding—planer knives, twist drills, milling cutters, saws and molding bitts have been so ground for many years. In an old copy of Appleton's Applied Mechanics there is an illustration of one of the early patterns of Sellers' twist drill grinder, which seems very crude in comparison with their 1893 pattern, which latter combines all the advantages of the former designs, with an improved chuck of enlarged capacity to hold and grind drills from one-quarter-inch up to three-inch diameter. This chuck is positive in its grip and holds the drill firmly against its centre. It grinds either twist drills or flat drills, and the water does not pass through the adjusting portions of this chuck. New drills ground only on this machine do not wear against the sides of the holes in drilling and thus become of a reduced diameter at the portion of drill most frequently in the metal when drilling, because they drill round holes of the diameter of the drill, and the drill runs central in that hole, thus making the use of a reamer seldom, if ever, necessary. Using water freely in grinding, the temper of the drill is uninjured, while by automatically grinding the edges of the drill to the most useful angle of



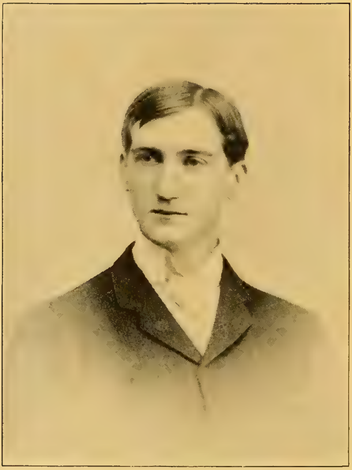
EXAMPLES OF TOOLS FINISHED TO SHAPE FROM FORGINGS ON THE SELLERS TOOL GRINDING MACHINE.

cutting edge, no matter what the diameter of the drill, less metal is wasted through frequent sharpening of the drill. This automatic varying of angle of cutting edge, is very important, as it must be borne in mind that the outer corner of the cutting edge of a drill describes the largest circle of any point on the cutting edge ; it also performs the greatest duty in cutting and removing metal and, furthermore, it revolves at the highest rate of cutting speed, all of which cause it to become dull the most rapidly, and need a stronger angle than is desirable nearer the centre of the drill. The face of the emery wheel is kept true by traversing the work when grinding. This new pattern includes a drill pointing attachment for thinning the point which becomes thicker as the drill is worn shorter, and also an attachment or supplemental machine for sharpening drills from one-sixteenth to five-sixteenth inches inclusive, which can be attached to the frame of the larger machine or can be used independently upon a bench, as shown on page 244.

Since the completion of an accurate wet-working tool grinder, grinding automatically as adjusted to any desired shapes except concave, many of the best engineering and railway shops are so shaping and sharpening their general machine shop tools. Such a grinder is shown also on page 244.

One peculiar advantage of this machine is the use of a circular wheel, double-beveled on the edge, which gives a line contact only with the tool ground in any and all positions, so that the steel is easily flooded with water to prevent heating. The general design also gives strength, freedom from vibration and accuracy of grinding. The adjustments of this machine are innumerable. Any shape of cutting point conceivable as needed (except concave) can be designed and accurately duplicated by the score ; or, after one is shaped and ground and the angles at which the machine was set are recorded, the machine may grind any other shape wished and then at any subsequent time desired, which may be a few moments, or perhaps a few months afterward, by resetting the machine to those recorded angles, an exact duplicate of that former tool is ground. This is not only one of the most accurate, but one of the most "intelligent" machines ever designed for using a grinding wheel. As one mechanical engineer, who is using this machine, expresses it, "He can design the best shapes of tools for his workmen and know that they are being used without making a policeman of himself." Some odd shapes ground on this machine are shown on the preceding page.

Four of them in the lower left hand corner were designed for turning multiple threads in feed screws for planer beds and have no right angle in the cutting parts, but are shaped and sharpened accurately and duplicated as readily as the simplest right or left hand roughing tool for cast-iron.



Francis O. V. Blackwell
Nov. 29th 93

POWER TRANSMISSION LINE NEAR OURAY, COL.

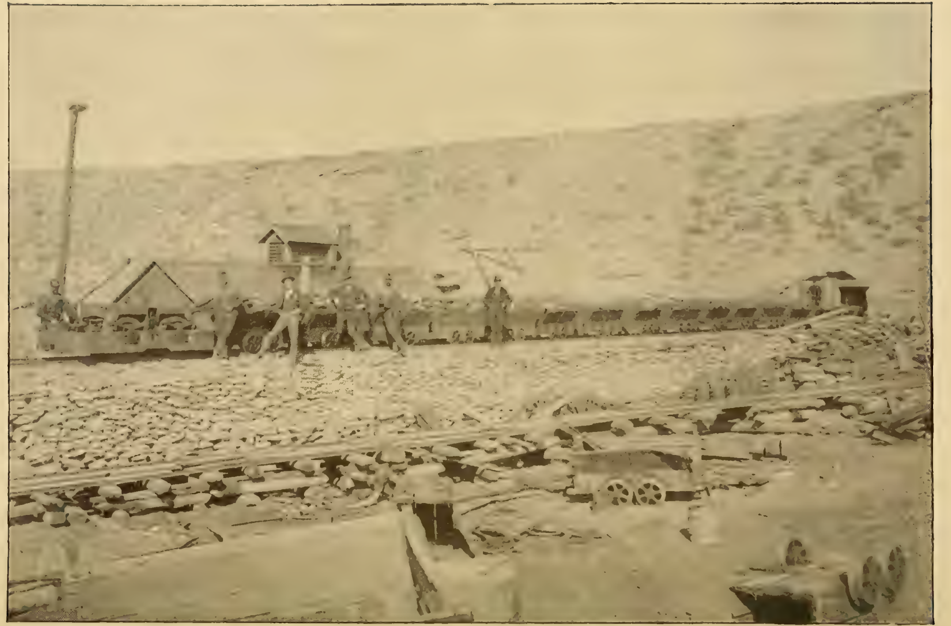
ELECTRICITY IN MINING.

By F. O. Blackwell, M. Am. Inst. M. E.

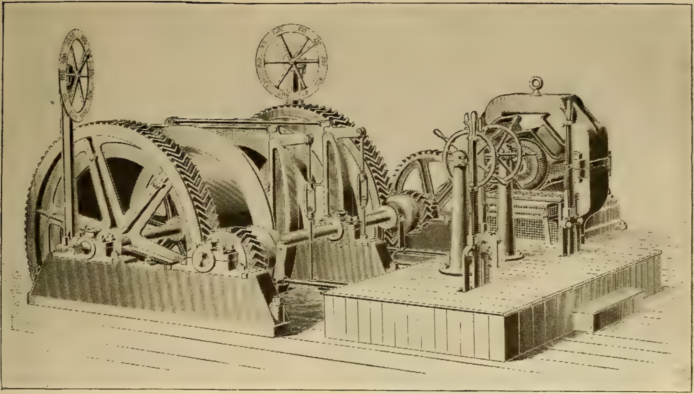
Mr. Blackwell is engineer of the Power and Mining Department of the General Electric Company, with headquarters at Lynn, Mass. He graduated at Princeton in 1887, and during 1889 was superintendent of the Bentley-Knight Electric Railway Company.

TREATING of the various applications of electricity to mining, in a paper read before the late International Engineering Congress at Chicago, the author roughly estimated that some three hundred companies in the United States engaged in mining and the kindred arts now employ this agent in their operations. As all these plants have been installed within the last few years, it is evident that mining engineers have been quick to appreciate the great advantages of the use of electricity and adopt it for their many requirements. In underground workings the chance of accident resulting in loss of life and destruction of property is, at the best, great. Humanity and economy both demand that any means that will secure greater safety should be eagerly grasped. It is an established fact that to add to the comfort and facilitate the work of the miner is to diminish financial risk and increase profits.

Electricity tried under the arduous conditions of mining service has been shown to be peculiarly efficient, safe and reliable. It presents a system of the greatest simplicity, completeness and flexibility, permitting power from one source to be distributed in units of any desired size and for any purpose to the places where it can be employed to the greatest advantage, thereby securing the minimum consumption of power and expenditure of labor. With electricity there is neither friction, heat nor condensation. There is no leakage nor loss of power when not in use, which especially recommends it for intermittent work. It is not affected by heat or cold and does not vitiate the air, as is the case with steam and compressed air. The rapid deterioration of timbering, a source of great expense in all mines, due to bad air and heat, is to a great extent obviated. It has been urged against electricity that it increased the risk of fire, but as a matter of fact it greatly decreases it, as the



AN 80 HORSE-POWER ELECTRIC LOCOMOTIVE WITH 30 CARS, AT ROCK SPRINGS, WYO.

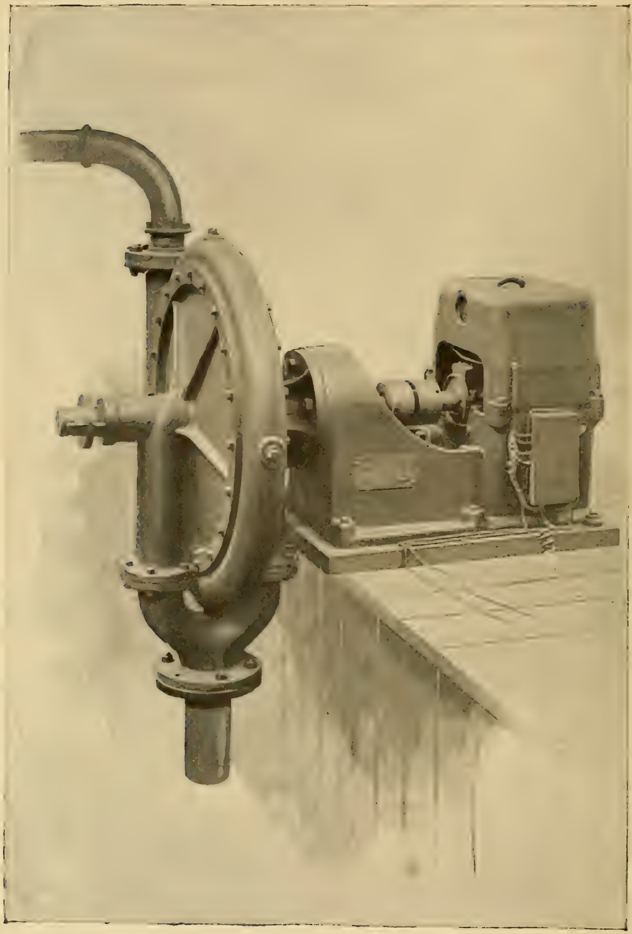


150 HORSE-POWER DOUBLE-DRUM ELECTRIC HOIST.

statistics of insurance companies testify. With proper safety devices and a system of concentric wiring it is practically impossible to start a fire from the current. To the engineer accustomed to speed indicators, pressure gauges and indicator cards, electrical methods of measurements seem particularly simple. The work being done by motor or generator at any instant can be read directly from a scale and, if desired, can be automatically recorded. If necessary, motors can be controlled from a distance without difficulty.

The prime source of power is first to be considered. By coversion into electrical energy, water power, even at a considerable distance from the mine or mill, can be made valuable for all purposes, and steam power can be so located as to secure fuel and water cheaply. In addition to this, one large engine costs less, is more evenly loaded, requires less attendance, and is necessarily more efficient than a number of small ones. The introduction of electricity has in this way made important reductions in the cost of power, and there are cases in which it would be impossible to run without its help. An example is furnished by the Virginius mine at Ouray, Col., to which 300 horse-power is carried at 800 volts from a water-power four miles distant. The cost of coal at the mine was formerly $18 per ton, which would amount, for the present plant, to about $80,000 per year, equaling the total cost of the electric plant. The item of fuel was a complete saving, the expense of operating the steam and electric plant being about the same in other respects. Several mines in Colorado are operated by electricity that could not be by steam, on account of their situation on the face of precipitous cliffs up which the transportation of water and fuel would be nearly impossible. The character of the country over which the power had to be carried for the Virginius plant is exceedingly rough. A portion is at an elevation of 12,000 feet above sea-level and well above the snow-line.

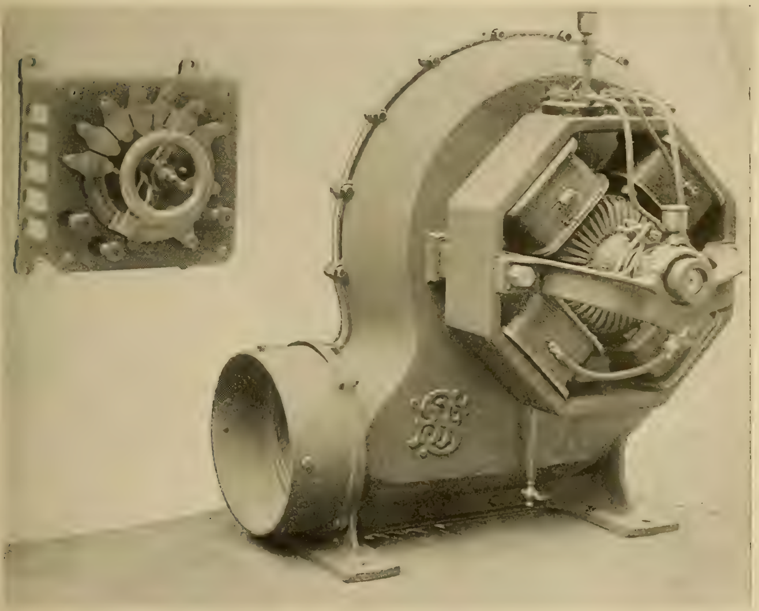
Electric generators can now be obtained of any size and designed to run at any reasonable speed for belting or direct connection to engine or water-wheels. The largest generator in the world, which ran in the power station of the Intramural Electric Railway at the World's Fair in Chicago, is of 2000 horse-power, and directly connected to a compound condensing engine running at seventy-five revolutions. The electric generator is substantially the same



CENTRIFUGAL PUMP WITH DIRECT-CONNECTED MOTOR.

as the motor, and both can be relied upon to give an efficiency of from ninety to ninety-five per cent.

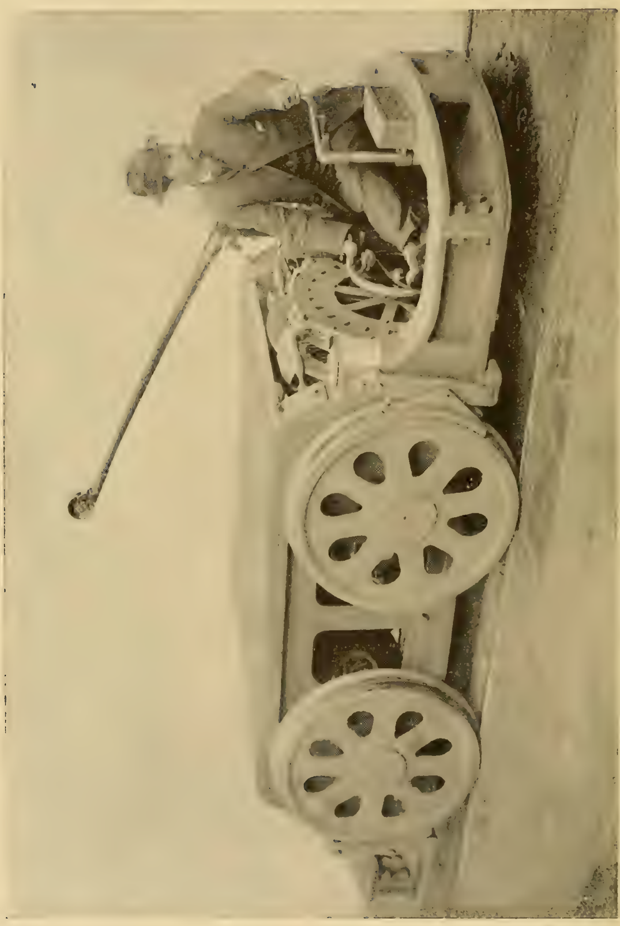
As regards electric transmission and distribution it should be stated that the cost of copper, with any fixed loss, power, and distance varies inversely as the square of the voltage. It is, therefore, evident that as high a voltage as possible should be used if economy of copper alone is to be considered. When the power is carried over long distances the cost of copper is the largest item of expense. For general distribution, especially underground, convenience of insulation and handling are of more importance and call for a low potential. Nearly all the plants now in operation are supplied with current at 220 or 500 volts. There are a number, however, in which voltages of 1000 and over are in use—notably at the Poorman, Comstock, and Calumet and Hecla mines. When bare wires are used, as for haulage, we are limited to a potential of 500 volts. Direct-current generators are confined, by difficulties of construction, to potentials of less than 1500 volts. The distance over which direct current can be economically carried at this potential is about four miles. Above this point alternating currents are used.



AN ELECTRIC VENTILATING SET.

The long distance transmission of power was first brought prominently before the public by the experimental line constructed between Lauffen and Frankfort two years ago. The power of the Lauffen Falls was converted into electricity, transmitted 115 miles to the Exposition at Frankfort, and there operated a number of motors. The distance was beyond the limits of commercial success, but it demonstrated the possibility of the system. To-day, plants are in operation, transmitting current for light and power at Walla Walla, Wash.; Portland, Ore.; Redlands, Cal.; Telluride, Colo., and Hartford, Conn. The distances vary from four to thirteen miles.

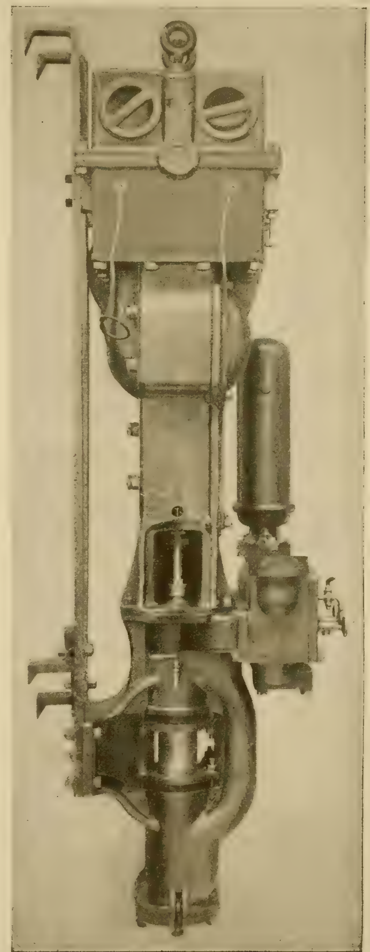
Alternating currents are particularly desirable, on account of the ease with which the electrical pressure can be changed. By means of transformers without moving parts, the high potential used for transmission is converted into low pressure for distribution. Alternating generators are wound for as high as 5000 volts, but it will probably



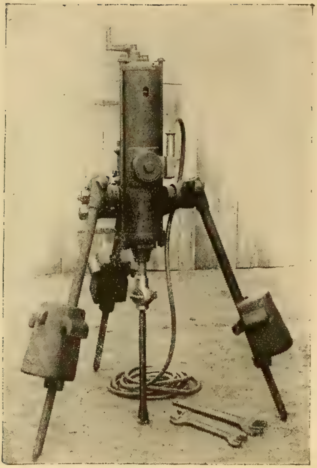
A 50 HORSE-POWER, TWO-MOTOR MINING LOCOMOTIVE.

be found better to limit them to 2500 volts. This potential permits of economical transmission to a distance of seven or eight miles. Above that distance, step-up and step-down transformers are used. At present we do not care to go above 10,000 volts, which places the limit of about twenty-five miles to practical work. Alternating current motors possess nearly the same properties as those built for direct current. They have the advantage of being commutatorless, but cannot be so heavily overloaded as a series-wound direct-current motor. They are, therefore, not as suitable for railway or hoisting service. Direct current can, however, be readily obtained from alternating by means of a rotary transformer, which is a combined alternating motor and direct-current generator. Motors have been designed to meet all the special requirements of mining work, and I will give a short description of some of the more recent applications.

In no application of electricity, except lighting, has such success been met with as in the operation of railways. Above ground, it has already largely supplanted animal power, and in many cases steam. For underground haulage, the ready control, compactness and freedom from smoke, render it still more desirable, and already electric locomotives are in some forty mines. I would call particular attention to the saving that can be effected in the size of entries. The electric locomotive is so designed as to occupy no more space than the car which it is to haul. With any other method of traction considerably more height or width is necessary. In coal mines, in which there are narrow seams, this is especially noticeable, as much rock has to be blasted away to admit of the passage of mules. By using electric locomotives the blowing down of the roof is entirely done away with. The increased speed also permits a larger tonnage to be taken from the same outlet and with fewer turnouts, switches and cars. Locomotives are now to be obtained of any size, and to operate on any track-gauge not less than eighteen inches. The Baltimore and Ohio Railroad Company, after carefully considering all systems, decided to equip their tunnel through Baltimore with electricity, and push through all their trains by electric loco-



ELECTRIC SINKING PUMP.

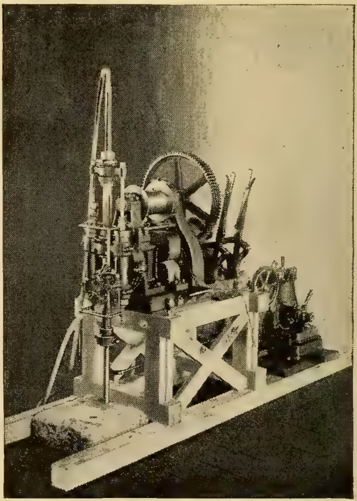


AN ELECTRIC PERCUSSION DRILL.

motives. The first of these locomotives was recently completed at the Schenectady works of the General Electric Company. Its weight is ninety tons, and at fifteen miles per hour it will develop 1500 horse-power. For mining haulage large sizes are not required, those now in use varying from 150 to ten horse-power, the most common size being thirty horse-power. In the illustrations accompanying this paper two types of locomotives are shown. At Rock Springs, Wyoming, there is in operation a locomotive of eighty horse-power. It is operated by a single motor, geared to both axles, the connection to the axles, however, being made through a flexible coupling, allowing the entire weight to be supported on springs. The fifty horse-power mine locomotive, shown on page 254, is driven by two motors, one on each axle. It will be noted that no part of the machine is higher than the wheels.

The larger size of locomotives, generally, are constructed with one motor, and the smaller with two. All locomotives in use are controlled by rheostats, and the speed under load varies from six to twelve miles per hour.

Electric hoists are now largely in use, and follow as nearly as possible the methods and construction approved for steam hoists. The governing mechanism is similar, rheostats replacing the steam controlling gear, and the brakes and clutches are the same. The rotary motion of the motor avoids the use of connecting rods entirely. If it is desired to lower by power the current can be admitted to the reversed motor. For small hoists used in winzes and in timber construction work electricity is well adapted, the power connection being easily and quickly changed. The simplicity of the application of electricity, and the consequent economy, is well exemplified in the equipment of the Brooklyn docks of the Wilson steamship line, where nine electric hoists, constructed by the General Electric Company, have been in continuous operation for two years, with a total cost of repairs of $23. The double-drum hoist, shown on page 251, is designed for a double compartment shaft. It is furnished with post brakes and jaw



A ROTARY DIAMOND DRILL WORKED ELECTRICALLY.

clutches of the ordinary pattern. Special hoists, for use underground, are equipped with ironclad motors so as to be thoroughly protected. An efficiency of from fifty to sixty per cent. is usually obtained between the power taken by the motor and the foot-pounds hoisted.

A number of large pumping plants are now in operation equipped with electric motors. It is necessary, in order to turn the reciprocating motion of a plunger pump into a rotary motion, to equip it with crankshaft and connecting rods. This, at the same time, insures a steady flow of water. Some difficulty is experienced in cutting down the speed of electric pumps, as is done with steam. The general practice has been to stop and start, in order to decrease the capacity. The best method, and one going largely into use, is to make the fields of such strength as to give the minimum speed desired, so that, by decreasing the current in them, the speed may be increased up to the maximum output. Where many pumps of nearly the same size are in operation a convenient method of regulation is to throw the pumps into multiple series combinations with each other. They may also be controlled by varying the electromotive force supplied them from the generators. Rheostats answer well enough for small pumps. Triple single-acting and duplex and triplex double-acting all work well and give an efficiency of over seventy per cent. between the electric power taken by the motor and the water delivered by the pumps. If the lift is small and the water contains much solid matter, centrifugal pumps may be used, but their efficiency is low. At the World's Fair exhibit of the General Electric Company was shown a Blake pump directly connected to a slow speed multipolar motor of 100 horse-power, requiring only one gear reduction. The capacity of the pump is 500 gallons at 500 feet head. On page 255 is shown a sinking pump of 120 gallons capacity, to work against 200 feet head. It will be noted that the motor and gearing are completely inclosed in a cast-steel case, and cannot be damaged by being flooded.

The statements made above regarding hydraulic pumps apply equally well to air compressors, except that, as air has not the inertia of water, the compressor can be automatically loaded and unloaded without throwing any strains on the mechanism, the motor running at a fixed speed. A decided saving of power can be effected by locating drill compressors near to the drills and thus avoiding losses by leakage and shrinkage in the pipes.

Although it has been a matter of great difficulty to make an electric percussion drill which would stand the continual abuse and hard usage to which air drills are subjected, they are at present in constant and successful operation. By care in designing the coils, so as to make them fireproof and rigid, they have been made to stand the strain. The drill consists of an outer iron pipe-casing, inside of and attached to which are two coils and ratchet mechanism. The plunger, equipped with the ordinary chuck and riflenut, is in the centre of the coils. The coils are supplied with current alternately, and draw the plunger up and down at a speed fixed by the generator which supplies the current. An electric drill mounted on a tripod is shown on the opposite page.

Electric diamond drills are in use for drilling solid holes and for removing cores for prospecting purposes. For prospecting, both above and under ground, the electric drill is particularly available as it is extremely light and compact and temporary wires can be run to places where it would be difficult to carry steam pipes or boilers. The diamond prospecting drill with hoist and pump, shown on page 256, is driven by a 2¾ horse-power motor. It will remove a 1⅜-inch core, and can drill 600 feet deep without difficulty.

Electric coal cutters are now largely in use in the bituminous mines. In the machine most employed the coal is undercut by means of bits set in a rotary bar on the end of a sliding frame which is fed into the face of the seam. Other cutters are constructed with a sprocket chain, to the links of which are affixed cutting tools. Machines of this kind can be fed either in or along the face of the coal, for long wall or room working. In both of these the electric motor is built into and forms part of the frame, adding but little to its weight. In exceedingly hard or pyritiferous coals, which cannot be cut with a continuously moving cutter, an electric pick machine is advantageously used. This also has the advantage of giving a kerving wider at the front than at the back of the cut, which allows the coal to fall outward, and more lump coal to be gained. The motor draws a projectile back against a spring and, releasing it, lets the pick fly against the face of the coal at the rate of 150 blows a minute. Electric drillsfo r putting in holes for blowing down coal after it has been undercut or from the solid, as is done in anthracite, are also used. Mounted on a column, a machine of this kind is free to drill in any direction, from horizontal to vertical. A drill ot this type, of 100 pounds' weight, will easily drill a 1½-inch hole at the rate of six feet per minute in hard or soft coal.

In order to obtain the best results from fans and blowers for ventilation, it is often desirable to locate them at the most distant points from the surface. This is done more easily in the use of electricity than of any other power, and the blowers can be readily advanced as the workings are pushed deeper. The electric motor is especially suitable for high speed blowers, which are efficient and occupy but small space. Much saving in piping can also be effected by using higher velocities and forcing air out from the inside rather than sucking it from the surface. Fans can be controlled by a shutter on the outlet pipe, or the speed of the motor may be varied.

It has been found that much more work can be got from men by giving them better illumination. By avoiding the use of oil lamps and candles, the air is left purer, and both time and power are saved by doing work underground which would otherwise have to be done on the surface. Electric lighting also reduces the risk of accident by calling attention to conditions which would otherwise pass unnoticed. In gaseous mines, where many explosions have resulted from the reckless use of miners' lamps, electric lighting is invaluable.

It is impossible to go fully into the electro-metallurgical and electro-chemical processes now in use. The refining of black and blister copper has reached large proportions, fully one-third of the copper refined in the United States being electrically treated, and considerable quantities being shipped abroad. By this process gold and silver are obtained from the matte, the recovery of which would be impracticable by any other method. Gold, silver and lead are also beginning to be refined electrolytically. Aluminum and silicon are produced almost exclusively by electric smelting and reducing. Caustic soda, sodium, chloride of lime and vermilion are commercially obtained by electrolysis.

I have not, within the scope of this paper, been able to deal with all the many and constantly increasing applications of electricity, but enough has been said to make evident its far-reaching importance to the mining industry.

Wm H. Wiley
Dec. 1893

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

FIRST GENERAL MEETING, AT NEW YORK CITY, NOVEMBER 16, 1893.

By William H. Wiley, M. Am. Soc. M. E.

Mr. Wiley, who is a graduate of the College of the City of New York, after serving through the Civil War, received the degree of civil engineer at the Rensselaer Polytechnic Institute, and at once entered upon an active professional career. Later, he took a special course in mining engineering at the Columbia School of Mines. He is now a member of the well-known firm of John Wiley & Sons, publishers of scientific text-books, and has been treasurer of the American Society of Mechanical Engineers continuously since 1884. He is also a member of the Civil, Mining, and Electrical Engineers' Societies, and of the Engineers' Club of Philadelphia.

THIS is most emphatically an age of Progress, and in no way is this better demonstrated than in Science. The advance in the methods of application of existing knowledge, and the constant pursuit into new fields, has resulted in a state of things of which the ancients, and, indeed, men living never dreamed. In the older times, and in moderately modern ones, an engineer was a man who was expected to turn his hand and brain to almost anything from mending a water-wheel to building a factory, and from fixing a machine to constructing a road or devising a system of drainage. In the more modern times he was a little better than a skilled mechanic, or a clever fireman. In the navy, within the writer's knowledge, he was known as a "greaser," and was not considered as fit to be a ward-room officer. What wonder then that no remarkable advance was made by men in such a condition.

But to-day all is changed. The engineer has found that no general knowledge of his profession will suffice, and, like medical science, engineering is divided into specialties. The field is too great for one man to deal with various problems in different lines of progress. To succeed he must be a specialist in some one great branch of this grand profession,—this grandest, indeed, of all professions. To cope with the forces of Nature certainly enlarges a man's views of matters and things in general, and engineers, as a rule, are free from the petty bickerings and jealousies incident to a struggle for supremacy among men in a lower plane.

One of the immediate results of the division into specialties of some branch of engineering, is the formation of societies dealing particularly with these subjects. The writer remembers very well that when the American Society of Mechanical Engineers was formed, quite a number of the original members came from the Civil Engineers. It was a common remark that there was no need of such a society as the Mechanical Engineers, and that certain papers in the Civil Engineers' Transactions could be given to a discussion of mechanical subjects. Why not make chapters, or do anything but start a new society. This was the old fogey cry. As a matter of fact, however, the Mechanical Engineers' Society did not weaken in any way the Civil Engineers.

If it had any effect it was to strengthen them, for many a man who joined the former society at that time, has since joined the latter, feeling that this great body could not but be a benefit to him, and now we have two great organizations about equal in numbers, with a large membership belonging to both, working side by side in perfect harmony, and each one influencing and stimulating the other.

Another step into special study is the formation of the organization whose first meeting this paper chronicles. The ship carpenter has developed into a naval architect, just as the "greaser" has become a marine engineer, and a glance around the assembly gathered in the auditorium of the Mechanical Engineers' house at New York, on the night of the first meeting of the new body, showed the high standard which it had attained at this early period of its existence. In the chair was the able and accomplished president of the International Steamship Company, Mr. C. A. Griscom, and on the platform was Naval Constructor Francis Bowles, to whom is given the credit of founding the society. Around the well-filled hall were many familiar faces, men of affairs whose names are known in both hemispheres, — Mr. Charles Cramp, whose new cruiser has just demonstrated her claim to be the fastest war ship afloat, and thereby put $350,000 bonus into the pockets of the enterprising firm who built her; Commodore C. H. Loring, late engineer-in-chief in the U. S. Navy, and to-day, although on the retired list, one of the best consulting engineers in the country; Mr. Warren Hill, vice-president of the Continental Iron Works at Brooklyn, N. Y., where the first monitor was constructed; Mr. W. M. McFarland, assistant engineer in the U. S. Navy, to whom was due the carrying forward of the Marine Congress at Chicago, and who is to-day one of the rising men in his profession; Prof. C. H. Peabody of the Massachusetts Institute of Technology, a brilliant and powerful writer and instructor; and the following men of distinction, who are well known as successful engineers or as distinguished scientists: Messrs. Andrew and William Fletcher and Mr. Stevenson Taylor, Charles H. Haswell, H. B. Roelker, Charles E. Emery, R. W. Davenport, J. F. Holloway, Col. E. A. Stevens, William Gardner and his partner, C. D. Mosher, Col. H. Grant, M. N. Forney, Professor James E. Denton, Chief Engineer Henderson, James T. Boyd, Charles Kirchoff, S. D. V. Burr, J. J. Woodward, U.S.N., and a host of others. The society numbers 435, although not one year old, and is able to start this coming year with an encouraging balance in its treasury.

The chairman inaugurated matters with a pleasant address, congratulating the association on the happy coincidence of being born at the time when this nation was developing a new navy. He cited the need of a merchant marine to sustain the new navy, and complimented some of the designers present on the magnificent specimens of their handiwork plying the waters of the United States and the coasts of the country. Modesty prevented him from speaking of the coming triumphs of his own line, but his hearers may rest assured that the Lucania and Campania will not hold the ocean record when Mr. Griscom's company gets its new ships from Philadelphia. The following results of the election for the ensuing year were then announced: President, C. A. Griscom of the International Navigation Company; first vice-president, Theodore Wilson, late Naval Constructor U.S.N.; vice-presidents, C. H. Cramp of William Cramp & Sons; George W. Melville, Engineer-in-Chief U. S. N.; George W. Quintard of the Quintard Iron Works; Irving M. Scott of the Union Iron Works, San Francisco; Francis A. Walker, president of the Massachusetts Institute of Technology; William H. Webb, one of the fathers in the profession; C. H. Loring, late Engineer-in-Chief U. S. N.; Philip Hichborn, Chief Constructor U. S. N.; and Commodore R. W. Meade, U. S. N.; secretary and treasurer, L. Capps, Assistant Naval Constructor, U. S. N.

These matters of business having

been disposed of, the society settled down to listen to the papers and the discussions thereon. The first paper was "The Evolution of the Atlantic Greyhound," by Charles H. Cramp.

He claimed that ocean racing commenced really when the City of Brussels broke the eight-day record in 1869 by making the run in 7 days, 22 hours, 3 minutes. Her engines were simple, direct-acting, with two 90-inch cylinders of 54-inch stroke, of about 3000 horse-power. Her speed was 14½ knots, her length 390 feet, and her breadth about 40 feet. The White Star Company answered this record with the Oceanic, 420 feet long, and 40 feet in width, having two compound engines, the high-pressure cylinders being 29 inches and the low pressure 78 inches in diameter, with 60-inch stroke. Then came successively the Adriatic and Celtic, and the record to 7 days, 16 hours, 26 minutes. The American Steamship Company then put out the Carolina, Illinois, Pennsylvania and Ohio, all eight-day ships. The City of Berlin brought the record to 7 days, 15 hours, 28 minutes, but the Germanic and Britannic cut it down to 7 days, 6 hours, 52 minutes. In 1879 the Arizona reduced it to 7 days, 3 hours, 38 minutes, and this was followed by the Alaska and City of Rome, and the time was 6 days, 18 hours a boat. The America brought it down to 6 days, 14 hours, 16 minutes, and the Oregon to 6 days, 9 hours, 22 minutes. Then the Umbria and Etruria crossed in six days, which was the time in 1889. This marked the exhaustion of possibilities on a single screw, and the twin screw was looked forward to as the future necessity to lower the record, and we therefore came to such ships as the New York, Paris, Majestic, Teutonic, Campania and Lucania, whose records and descriptions the author thought were too well known to need any detailed remarks. He then proceeded to call attention to the principal "fad" of English builders, viz., their aversion to statical stability,—a repugnance to metacentric hight. "A ship will roll; you cannot help that;" so they decide to make her roll long, and her motion easy. The writer will confirm this view of Mr. Cramp, for he has crossed on the New York and the Paris; the former rolls and the latter does not, yet both are built on the same lines and by the same builders.

Mr. Cramp proceeded then to condemn water ballast on the ground that to carry 2000 tons of dead weight to supply that stability lost by coal consumption was a subject he had no patience to discuss. He closed with an account of the two new ships building for the International Navigation Company at his company's yards. The length is on the load water line 536 feet; length over all, 554 feet; extreme breadth, 63 feet; molded depth, 42 feet; gross register, 11,000 tons; 1st cabin capacity, 320 passengers; 2nd cabin, 200 passengers; 3d cabin, 900 passengers. They have twin screws, and quadruple expansion engines, which, with steam pressure of 200 pounds, will develop collectively 20,000 indicated horse-power. The outward shaft bearings are supported by building out the hull in a horizontal webb, to a steel frame having both bosses cast in one piece, weighing 68,000 pounds. The keel slopes up so that the shoe meets the boss frame at the after end, the after dead wood being cut away.

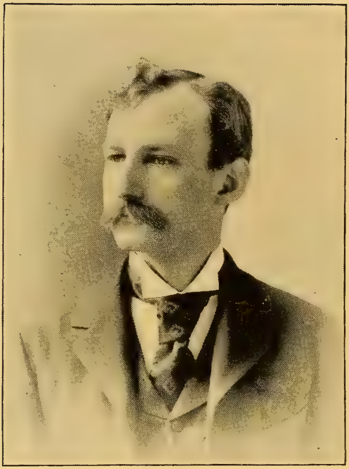
The next paper was by James T. Boyd, and was a criticism of the present inspection laws relating to machinery and boilers. He favored a complete revision of the rules and an increase in the number of inspectors. "Coal Bunkers and Coaling Ship," was by Lieut. A. P. Niblach, U. S. N. He proceeded to show the impossibility of rapid coaling in the case of naval vessels because of the location of the bunkers, and recommended the extension of them in cruising ships to the width of the deck, and their division by a fore and aft bulkhead amidships.

A paper by Mr. Theodore D. Wilson described the "Steel Ships of the U. S. Navy." It was accompanied by drawings of the types of all the new vessels. He stated that since 1883 we had added 43 vessels and two torpedo boats to our navy, and paid a high compliment to the work which had been done in private yards, stating that all but four had came from such sources, and that in no case had the vessel failed to develop the contract speed.

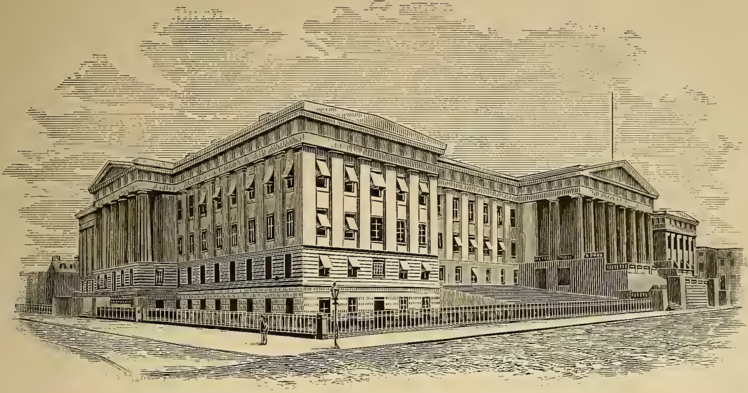
"The Performance of American and Foreign Freighting Ships" was presented by W. W. Bates, late Commissioner of Navigation. It was extremely laudatory of American constructors, and showed that their work had proved superior to that of any foreigner.

Col. E. A. Stevens presented "Some Thoughts on the Design of New York Ferryboats," showing what were the characteristics of a good ferryboat, and describing the action of screw boats and their adaptability to this service. The writer, who uses the boats of Col. Stevens' company twice a day, and has done so for years, desires to bear this testimony to their perfectness, and also to the management of the Colonel's able assistant, Capt. Woolsey, the superintendent of the Hoboken Ferry Company. These boats are unequaled for general utility, as well as for the comfort of their passengers, and as such are models to any other ferry company around New York or elsewhere.

Many other papers of great interest and of practical value were presented, and all received careful discussion, notably that of Chief Engineer George W. Melville," entitled "Notes on the Machinery of the New Vessels of the United States." The author considered it a mistake to build small vessels with a high speed for duty as cruisers. He took the ground that, as a rule, in times of peace they were never called to exert anything like their capacity; they carried around a large weight of engines and boilers which, although desirable in war, were useless in the normal condition of things. The other papers were entitled "The Influence of Speed and Weight of Machinery on the Determination of the Other Elements of Design of Steam Vessels," by J. J. O'Neill, Naval Architect and Marine Engineer; "The Wetted Surface of Ships," by D. W. Taylor, Naval Constructor, U. S. N.; "On the Law of Frictional Resistance," by Prof. W. P. Durand, Cornell University; and "Steam Yachts as Naval Auxiliaries in Time of War," by William Gardner, Naval Architect. This completed the session, and after a dinner at the Brunswick, which served to draw each member more closely to his fellow, this notable gathering separated, and the first meeting of the Society of Naval Architects and Marine Engineers passed into history.



Edward P. Thompson
December, 12, 1893



THE UNITED STATES PATENT OFFICE AT WASHINGTON, D. C.

PROTECTION OF INDUSTRIAL PROPERTY.

By Edward P. Thompson, M. E.

Mr. Thompson has for a number of years not only made patent laws of different countries the subject of careful study, but has been engaged in many international patent suits, and has obtained patents in every civilized country. He graduated at Stevens Institute in 1878, receiving the degree of mechanical engineer.

JUST before the adjournment of the last Congress, the Senate, in compliance with the recommendation of the Commissioner of Patents, in his last annual report, adopted a resolution to the effect that the Secretary of the Interior be directed to ascertain what legislation, if any, is necessary to enforce the provisions of existing treaties or conventions with foreign countries with respect to patents, or to secure to citizens of the United States the enjoyment of privileges in foreign countries corresponding to those enjoyed by the subjects of such countries in the United States, and to report his conclusions to the Senate at the next session of Congress.

The resolution shows a doubt as to whether any legislation is really necessary; but if it be true that there is no treaty in force, inventors are being very much deceived by the "Rules of Practice," published by the United States Patent Office. One of these clearly promises an inventor the advantages of a treaty, because it relates that an applicant who shall have regularly deposited an application for a patent of invention or of an industrial model in any foreign country that is a party to the treaty, and who shall present to be filed in the Patent Office of the United States his application for a patent for the same invention, and ask the benefit of the treaty, shall be required, simultaneously with the filing of his application, to file a duly authenticated transcript of the application deposited by him in such foreign country. The rule relates further that such authentication may be made in the manner and form prescribed by the laws of such foreign country or by the laws of the United States.

Many applications are being filed with a view of making use of the terms of the treaty, and in accordance with this rule, but a recent contested patent case in the knowledge of the writer disclosed the surprising fact that the United States Patent Office does not recognize that the treaty is in force. It is very important, therefore, that inventors who are citizens or subjects of countries belonging to the Union should be aware of this apparently misleading rule, which has been carried through successive editions of the printed rules of practice of the United States Patent Office.

The ground upon which the Patent Office rejects the operation of the treaty is the opinion of the Attorney-General, rendered to the Secretary of the Interior on April 5, 1889, who holds that the treaty is a reciprocal one ; that each party to it covenants to grant, in the future, to the subjects and citizens of the other parties certain special rights in consideration of the granting of like special rights to its subjects and citizens ; that it is a contract operative in the future infraterritorially, and that it is not, therefore, self executing, but requires legislation to render it effective for the modification of existing laws.

In view of the facts above stated it is now proposed to set forth briefly a few arguments why the United States Patent Office should recognize the force of the treaty. If the treaty is not in force in reality any patents based upon the treaty will stand a slim chance when contested in the courts or in the Patent Office.

The proclamation of the President of the United States, dated the 11th day of June, 1887, recites the convention and final protocol, exchange of ratifications, adhesion to the convention advised by the United States Senate, ratification by the President, and announcement of the accession of the United States to the Union by a United States minister resident. The act of the President should in no case be superseded by an opinion of the Attorney-General, because the opinion is extra-judicial while the administrative acts of the President of the United States stand good and valid in themselves, and as binding precedents and authorities unless, and until, overruled by a judicial determination. The opinion of the Attorney-General is only an individual opinion—provided for by law, but provided for as such only—while the act of the President, not overruled according to law, is an act of the law itself the same as the decision of a court. The one is subject to be followed or not—it is merely a suggestive guide—the other is an authoritative precedent, which may not be avoided by any but a court of competent jurisdiction. If the Patent Office could, upon any other basis than the judgment of a court of competent jurisdiction, avoid the proclamation of the President of June 11, 1887, then a private citizen could do likewise in any instance.

The very opinion cited shows that even the Congress of the United States, in a distinctly defined issue upon this very point of authority of the President and Senate to make and execute treaties, declined to conclude that its own concurrence was a pre-requisite, and merely resolved that it reserved the right to deliberate upon the expediency of carrying them into effect.

The Patent Office rules recognize the binding force of the International Patent Union in this country, and invite action thereunder and provide for such action. In order, therefore, that the Patent Office may disregard any alleged provision of law, as stated in its rules, it must have the authority necessary to supersede its own rules which exist in accordance with provisions of law ; it cannot have rules of procedure which it does not follow, although inviting the whole world to follow them. This power to supersede its rules is vested in no part of the Patent Office except the Commissioner of Patents, with the concurrence of the Secretary of the Interior. But this power has not been exercised and, therefore, the rule above mentioned is in force and has been continuously during the whole of the period under consideration. We have, then, an action of the Patent Office based upon an extra-judicial opinion of an Attorney-General, which sets aside and renders null and void the specific rule of the authorities lawfully constituted to prescribe rules for the Patent Office and all dealing with it, which rule is based upon the solemn international and contractual act of the President of the United States. It may, indeed, be true that legislation would appear to be necessary to render effectual an alleged (by the President) treaty of the United States, but it is held that it is beyond the lawful powers of the Patent Office to declare void a treaty of the United States, so alleged, even upon the basis of an opinion of the Attorney-General and in contravention of the rules prescribed by the Commissioner of Patents. It can scarcely be necessary, in view of all the premises existing in regard to the Union touching the obligations of the United States, to call attention to the stupendous results that would obtain if the contention of the Patent Office in this regard should be sustained.

In behalf of those who are not acquainted with, or have only a superficial knowledge of, the nature of the treaty under consideration, the following sketch is added, being confined to the treaty in so far as it relates to industrial inventions. In the year 1883 the Patent Union was concluded at Paris through the agreement of several nations. The United States became a member in 1887 by virtue of proceedings in the nature of an international treaty. Since that time one or two changes of countries have occurred, the members at present being Belgium, Brazil, France, Great Britain, Guatemala, Italy, Netherlands, Norway, Portugal, San Domingo, Servia, Spain, Sweden, Switzerland, Tunis and the United States of America.

The treaty provides that any one who shall have regularly deposited an application for a patent of invention or of an industrial model in one of the contracting States, shall enjoy, for the purpose of making the deposit in the other States and under reserve of the rights of third parties, a right of priority during the period of six months for patents of invention, and of three months for industrial models. These periods shall be augmented by one month for countries beyond the seas. The meaning of this may be better understood by an example. Suppose a United States citizen should file an application for a complete patent in Great Britain before issue of the United States patent. This is a common and very often a convenient procedure. Without the treaty his subsequent United States patent would expire three years earlier than the usual full term of seventeen years, *i. e.*, it would expire simultaneously with the British patent, and the inventor would lose the three usually most valuable years of his protection. The treaty is for the purpose of preventing this curtailment of the term, because it would give him seven months in which he might apply for the United States patent. *Vice versa*, he may apply in the United States first, in which case the treaty would give him seven months in which to file applications in foreign countries beyond the seas belonging to the union.

If it were not for the treaty, and if the United States patent were issued within the seven months and before applying in France, for example, the French patent would stand void, because of a prior patent in the United States. The treaty, therefore, becomes useful to United States citizens in those cases where the United States patent is promptly issued, and where it is desirable to apply for patents in countries belonging to the Union after the issue of the United States patent, and before the expiration of the six or seven months. The treaty is useless in those cases where the prosecution in the Patent Office occupies more than half a year; because after the issue of the United States patent, valid patents are unattainable in several of the foreign countries. If the inventions in the same line are numerous and require several patents which will naturally issue at widely varying dates, the handling of the several inventions for the object of filing them respectively on the same days in the different countries becomes inconvenient and exceedingly expensive, because a separate foreign patent would be required for each invention for the purpose of obtaining uniform dates in the foreign countries. If this uniform date is not necessary, one foreign patent in each country could include several of the inventions covered by the United States patents, because the foreign patent law is more liberal in regard to permitting one patent to protect many modifications.

Two ways have thus far been considered for overcoming the difficulty. One was proposed by the Commissioner of Patents and acted upon, but without success. He argued that there was, clearly, reason to believe that the period of priority (six or seven months) accorded to inventors for filing their applications or models in other countries than their own, was agreed upon without taking into full consideration the peculiar feature of the American patent system, which causes the term of a patent to begin with its date of publication, and not with the date of application, as in the other countries.

He expressed the opinion that the United States should be represented at the conference at Madrid, in 1890, by delegates learned in matters pertaining to the American patent law, in order that through the efforts of such delegates a change might, if possible, be effected which would make the treaty subserve the needs of American inventors seeking patents in foreign countries. To accomplish this result, it was proposed that the treaty be so amended as to make the period of priority begin with the date of publication of the patent first applied for instead of from the date of the application itself. Delegates were appointed, and presented the proposed amendment with well directed efforts, zeal and ability, but they were not able to accomplish the result anticipated.

The other way of overcoming the difficulty would consist in removing the peculiar feature of the American patent system above alluded to. The importance and value of the treaty seem to be sufficient to warrant this change, which would remove the peculiar feature not found in the systems of the principal countries of the Union. Of course United States patents would have a shorter term to the extent of the time occupied in prosecution, but at the same time the term of the patent should, out of justice to inventors, be altered to twenty years. It would be just also to the public, because inventors would push their cases with as little delay as possible. As an illustration of the working of this suggested change, it may be stated that if an inventor should file an application for a United States patent he would, within six or seven months thereafter, be entitled to a valid patent in any of the countries of the Union. At the same time the term of his United States patent would not be shortened. The best proof of its utility is the fact that it operates to entire satisfaction in other countries.

In his last annual report, the United States Commissioner of Patents states that at the next conference of the International Union, at Brussels, in 1894, it is to be hoped that the American delegates may be able to show to the other nations, which are members of the Union, that the Congress of the United States of America is fully sensible of the obligations assumed by the Government, and is prepared to execute them, or else that finding them inconsistent with our law, it has determined to withdraw from the Union.

The meaning of the phrase "industrial property" cannot be conjectured, nor can its meaning be found in the dictionary. It is a technical phrase, coined by the French, who frequently and almost habitually designate things by characteristic phrases rather than by single technical terms. No one could be positive in the interpretation of their phrase, "The State of Mosquitoes," which the author saw recently in a French newspaper, but the contents revealed the probability that they intended to refer to the State of New Jersey. They scarcely ever use the word "dead" or "died" even in their list of the dead, but they prefer to say "Breathed his last," or "Departed this life," and similar phrases. As to the phrase, "Industrial Property," the

French wish to convey the notion that property which is the production of the labor of the mind is industrial property; as, for example, mechanical inventions, trade marks, designs, literary and artistic inventions and music. Men of the present day are so accustomed to the idea of a legal right existing in behalf of inventions, that it is surprising that this right was first recognized only about two centuries ago, and fully established by any government not until the latter part of the last century.

An incident in the life of Crebillon was an early cause which led to the legal protection of the production of the mind. The invention in this instance related to literature, namely, the tragedy "Catiline." Crebillon, unfortunately, had several creditors, who attached his invention both as a book and as a play. Crebillon knew that in time the poetry which he had composed would be equivalent to many times his debts, and that it was, therefore, cruel that he should lose such valuable property. His petition is admirably worded, and as it could have been appropriately signed by any engineering inventor of this late day, it is reported in part below. The petition rehearses that the poem had been unknown, "that it should not be allowed to class among seizable effects, the products of the human mind; that if such a practice were permitted, those who had consecrated their vigils to the studies of literature, and who had made the greatest efforts to render themselves, by this means, useful to their country, would see themselves placed in the cruel predicament of not venturing to publish works, often precious and interesting to the State; that the greater part of those who devote themselves to literature require for the first wants of life those aids which they have a right to expect from their labors; and that it never has been suffered in France to seize the fees of lawyers and other persons of liberal professions." The King, Louis XV., promptly issued a decree in May, 1749, awarding protection to literary inventors. In the proclamation it was declared that the productions of the mind are not among seizable effects. Later, in 1762, the same king issued decrees relating to inventions in general, the special object being to limit the term of privilege to fifteen years, so that an invention could not be left as perpetual property to descendants.

The very earliest steps taken by any government, as far as present historical investigation shows, were those of James I., during or about 1622, when the first patents were granted. The patent laws of that time cannot be favorably compared with those of the present, because the former did not positively recognize an invention as a piece of personal property. The United States of America are entitled to the credit of first honoring and protecting inventors in a practical and effective manner.

The language employed in the law is explicit and amounts to a straightforward opinion that an invention is, for a limited period, the property of him who made it. In quick succession other countries issued decrees and passed patent laws. How unfortunate that they did not formulate laws which would aid the cause of international protection.

In general features, the laws are similar, but in details they are so conflicting and confusing that an inventor must know each law of each country and act in strict accordance with very limited conditions before he can be sure of international protection. While the countries are becoming more and more civilized and friendly the laws are becoming more and more modified, and several countries have combined together and have adopted a treaty which is intended to favor the inventor by modifying existing laws for a definite period.

By removing the "peculiar feature" of the American patent system; by increasing the term of the patent to counterbalance the loss of time due to the removal of the peculiar feature; and by declaring, by an act of Congress, that the treaty is and has been in force, the United States would share the same benefits long enjoyed by the other countries belonging to the Patent Union.

WASTEFUL USE OF EXHAUST STEAM.

By Albert Spies, M. Am. Soc. M. E.

Mr. Spies received the degree of mechanical engineer at Stevens Institute of Technology in 1881, at the age of nineteen, subsequently took up technical journalism in conjunction with other engineering work, practicing as consulting engineer for several years, and is now associated with CASSIER'S MAGAZINE.

ECONOMY from the use of exhaust steam from an engine for heating purposes has become so generally looked upon as a matter of course that it would seem to many almost like rank heresy to question the advisability, in any case, of utilizing so obviously valuable a waste product,—in fact to actually recommend throwing it away and substituting for it apparently more costly live steam from a boiler.

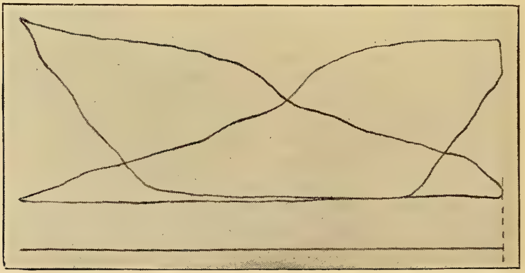


DIAGRAM FROM 12"X14" ENGINE; 272 REVOLUTIONS PER MINUTE. SPRING 40.

Every engineer knows that after steam has performed its legitimate function in a non-condensing engine and has there reached its limit of usefulness as a propelling agent behind the piston, it still possesses a very considerable amount of heat which can be profitably extracted in a variety of ways. For years, in fact, sermons were preached, and are still being preached, on the advantages to be derived from the several methods of turning this steam to some account, until, at last, owners of boilers and engines became educated up to that point where they recognized that by passing the exhaust through heating systems and feed-water heaters, instead of allowing it to escape directly into the open air, they could virtually get something for nothing. However little that something might be, it represented a gain, and plans for exhaust steam heating therefore readily commended themselves as unfailing sources of profit. So long as the steam is caught in some kind of pipe system, many steam users argued, and is there made to give up some of its heat, a certain degree of saving must follow.

That in laying out such systems, however, there are qualifications to be observed which may make all the difference between gain and loss seems to have been overlooked in many instances, and, as a consequence, suggestive results can be found in numbers, strikingly showing that exhaust steam may sometimes be profitably

Albert Spies,

December 5, 1893.

allowed to go to waste. Brief mention of one of several cases, known to the writer, may be of interest. The facts in the one here selected were ascertained in indicating an engine with the view of obtaining a proper basis for steam charges, a sample set of the several indicator cards which were obtained being reproduced on the preceding page. The back pressure observed amounted to about 15 pounds per square inch, and was due to the fact that the exhaust steam was passed through a series of coils of 2-inch pipe, placed in a tank which served as a feed-water heater. It was, of course, a question of some interest to the users whether this way of heating the feed-water was a good one, or whether better results could be obtained by pumping the water into the boiler at its normal temperature and allowing the engine to exhaust freely into the open air through a larger pipe, thus bringing the back-pressure down to the atmosphere or, at least, near it.

Figuring up the cards showed that the total amount of steam used hourly, at the observed back-pressure, was about 2255 pounds. The total heat in the steam exhausted per hour was, thus, 2,684,126 heat units, and this was found to raise the temperature of the feed-water in the tank through about 100 degrees. The amount of heat actually necessary to do this was, obviously, only 2255 x 100, or 225,500 heat units, so that of the 2,684,126 units, exhausted from the engine per hour, there were saved only the just-mentioned 225,500 units, or about 8½ per cent.

If this heating of the water had been done in the boiler, it would have required probably something like 22½ pounds of coal. With the feed-water heater not in use, and the back-pressure in the engine practically at the atmosphere, the steam used in the engine per hour was only about 1155 pounds, showing a saving of 2255—1155, or 1100 pounds. Assuming that the boiler was capable of evaporating 9 pounds of water per pound of coal, it becomes clear that $\frac{1100}{9} = 120$ pounds of coal were necessary to generate the surplus steam which, in passing through the heater coils, did work in heating which was equivalent to only 22.5 pounds of coal burned under the boiler. It seems almost needless to say that the heater was removed and that its owner had learned something about exhaust steam using that was in the nature of a revelation.

SMALL SIZES OF ANTHRACITE COAL FOR STEAM RAISING.*

By Eckley B. Coxe, Pres. Am. Soc. M. E.

Eckley Brinton Coxe was born in 1839, graduated from the University of Pennsylvania in 1858, and subsequently studied at the Ecole des Mines and at the Freiberg Mining School. In 1865 Mr. Coxe, in company with his brother, under the firm name of Coxe Bros. & Co., began the business of mining anthracite in the Lehigh region, and since that time has been engaged in the operation of his company's collieries.

THREE years ago I was appointed a member of a commission to investigate the waste of anthracite coal, and the question of the utilization of small sizes was studied with great care by us. The subject was treated generally in a report made to the State of Pennsylvania on May 30, 1893, and also in a paper which I read before the American Institute of Mining Engineers at their August meeting, upon "An Automatic Stoker."

When I first remember the anthracite coal business, all the sizes below stove coal were considered of little or no value. Chestnut coal was used to a greater or less extent about the collieries for making steam, but much of it was thrown away. It gradually became a domestic fuel, and pea coal took its place for generating steam. This size is gradually coming into use for domestic purposes, and buckwheat coal is taking its place for steam. Two smaller sizes, known as rice and barley, are already being used to a large extent for the same purpose. The value or cost of these coals decreases very rapidly with the size. I append herewith a table showing the size and approximate cost at mines, and the sizes of mesh over which or through which they are made.

Size.	Made Through. Inch.	Made Over. Inch.	Approximate Price at Mines.
Chestnut......	1½	⅞	$2.75
Pea...........	⅞	$\frac{9}{16}$	1.25
Buckwheat....	$\frac{9}{16}$	⅜	.75
Rice.........	⅜	$\frac{3}{16}$	.25
Barley........	$\frac{3}{16}$	$\frac{3}{32}$	.10

The above meshes are all round punched, and are the standards adopted by Coxe Bros. & Co. at the Cross Creek Collieries.

Another important point to be noted is, that the cost of transportation of the small sizes is less than that of the large. From the mines to tide, pea coal is charged thirty cents, and buckwheat, rice and barley fifty cents less per ton than the domestic sizes.

One great difficulty encountered in the introduction of these smaller sizes was the fact that, as they were of comparatively little value, but little attention was paid to their preparation, and parties who began to use them did not erect furnaces specially constructed for the purpose, but generally burned them in their old plants, sometimes changing the construction of their grate bars a little.

While the size of the domestic coals made by the different companies are practically the same, there has been a great difference in that of the small coals and in the amount of impurities contained in them. Formerly a large amount of culm was employed where it could be obtained cheaply, but its use is diminishing, for the following rea-

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* An extract from the presidential address delivered to the American Society of Mechanical Engineers on December 4, 1893.

Eckley B. Coxe

Nov. 24th 1893

sons: What was formerly known as culm contained the buckwheat, rice, barley, and in some cases the pea coal. Now, however, the pea, buckwheat, rice, and in some cases the barley are taken out, and the dust that remains, which forms what is now called culm, although it may be still used by mixing with bituminous coal, or in a special furnace in which it is burned as dust after being thoroughly pulverized, or by making briquettes or compressed fuel, is at present of no value alone and in its natural state for generating steam.

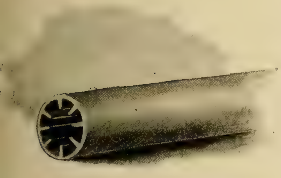
As is well known to all those who burn anthracite, sizing is of great importance. The coal burns only on the surface, and therefore, if the size is not uniform, the smaller particles clog the passages between the larger, and thereby prevent a sufficient quantity of air from passing through the furnace. Some of those who have attempted to use buckwheat, rice and barley have given them up, because of the great want of uniformity in the results obtained. The difficulty may be due to one of two causes, or both. First, to bad sizing, and second, to the presence of a large quantity of impurities. Experiments which we have made have proved that the percentage of carbon when small anthracites are burned under proper conditions, and not the size, is what determines the amount of water evaporated per pound of coal; but the amount of water evaporated per square foot of heating surface decreases with the size of coal.

Cheap steam is the corner-stone of a large number of our most important industries, and nothing is more important in obtaining it than cheap fuel. The enormous quantity of these small anthracites which we are now forced to make in preparing the larger sizes promises to furnish to the Northeastern and Eastern States a clean and economical fuel, which lends itself to mechanical handling far better than any other known combustible. The only thing that prevents every ton that can be produced from being used is the want of knowledge of its peculiarities and of proper methods of determining its value. In many parts of Europe coal is sold based upon the percentage of ash; that is to say, coal is guaranteed to contain not over a certain percentage of ash, and the price per ton is reduced a certain number of cents per ton for each additional unit of ash, and in some cases the deduction in the price increases in a geometrical and not an arithmetical progression, as the percentage of ash increases. It seems to me that it is of the greatest importance to the producer and user of the smaller anthracites that they should be sold on this basis, with an additional guarantee on the part of the producer as to the size. It is not simply a question of the absolute size of these smaller coals, but also one of the relative size of the different pieces which make up the aggregate; that is to say, each size should be as nearly uniform as possible. If we consider the coal to be made up of three sizes, Nos. 1, 2 and 3, No. 1 being the largest size, a ton of coal composed entirely of No. 2 would be much more valuable than one composed of the three, although the quantity of No. 1 in it might be greater than the quantity of No. 3. The smaller pieces tend to stop up the interstices between the larger lumps, and check the draft. It is one of the problems in burning small coal to force the air through a grate that will not let the coal drop, and through the body of coal which is more or less compact. Of course it is not practically possible to have the size of the coal absolutely uniform, but the producer should at least guarantee that a certain percentage of the coal sold as rice should be of such size that it would pass through a mesh of a specified diameter, and over a mesh of another specified diameter. In other words, with the present light I have upon the subject, if I was in charge of a large steam plant burning, say, 100,000 tons of rice coal per year, I would try to make a contract which would require the coal to contain not over a certain percentage of water and not less than a certain percentage of carbon, or, what is practically the same thing for anthracite, not over a certain percentage of ash, and that a certain percentage of the average daily sample of the coal would pass through a mesh of a certain size and over a mesh of another size, and that the coal should not contain more than a certain percentage of dust —dust being what would pass through a mesh of, say, one-sixteenth of an inch in diameter.

Current Topics.

A PECULIAR difficulty promises to present itself in the operation of the Trans-Caspian Railroad in Southern Russia. Not unlike snow storms and heavy drifts which add to the burdens of life of the railroad engineer in northern latitudes, sand storms along the lines which cross the sandy wastes of the Russian steppes make the task of keeping the roads clear a difficult one. A ready solution of the problem seemed to have been found several years ago in the planting of what is known as *saxonal* along the embankments, and in the free use of fascines of the branches of this growth to guard the rails. The plant throve in the sandy soil and satisfactorily accomplished the intended purpose. It was recently found, however, that the inhabitants of the various settlements which have sprung into existence along the line of the road discovered still another virtue in the plant and used it for their fuel in preference to coal and petroleum, cutting it down in large quantities for this purpose and thus denuding extensive tracts of land on both sides of the railroad. How to successfully guard against this new difficulty, which is said to seriously threaten the satisfactory operation of the line, is now the problem confronting the Russian officials, and stringent measures will probably have to be taken to put a stop to the practice.

ANENT the Serve boiler tube, of which brief mention was recently made in these columns, with special reference to its use on the locomotives of the Paris, Lyons and Mediterranean Railroad, it may not be amiss to state that the trouble from being clogged up with cinders, which has been suggested as a likely one, was, in point of fact, decidedly noticeable in some of the earlier trials. To overcome this, the expedient was adopted later on of reducing the height of the ribs and was found to answer the desired purpose quite satisfactorily, giving, of course, a greater clear draught area in each tube, and affording less opportunity for the wedging in of any solid substances that might be carried along by the usually powerful draught in a locomotive boiler. One difficulty, however, still remained and will be readily understood when it is remembered that the ends of a Serve tube must be reamed out for a short length, leaving them plain like an ordinary boiler tube, so as to permit expanding into the tube-sheets in the ordinary way. Pieces of half-burnt coal may find their way into the plain fire-box ends of the tubes, become lodged further in by striking against the ends of the ribs where they begin, and thus cause an obstruction. To guard against this, Mr. C. W. Whitney, of New York, the United States agent for the tubes, has patented a device in the shape of a malleable iron ferrule, corresponding in length with the plain part of the tubes where the ribs are removed for expanding, and cast with ribs corresponding in number, height, and position with the ribs in the tube in which it is employed, and of a sufficiently smaller diameter to admit of its being easily driven into the reamed-out part of the tube. The result is that he obtains practically one continuous length of ribbed tube, extending clear out to the fire-box face of the tube-sheet, and any solid pieces which might have entered the plain end of the tube, but which are too large to enter the reduced clear area of the ribbed portion must, therefore, simply fall back into the furnace. Soot and dust, which will collect in the tubes more or less, just as they will in plain tubes, can, of course, be removed by the simple use of a steam jet. One further advantage of Mr. Whitney's ferrule is that the relatively large body of metal which it contains causes it to expand, when heated, to a greater degree than the tube end itself, with the result of giving a more than usually tight joint between the tube and tube-sheet.



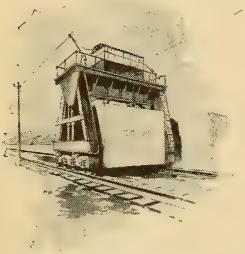
THE SERVE BOILER TUBE.

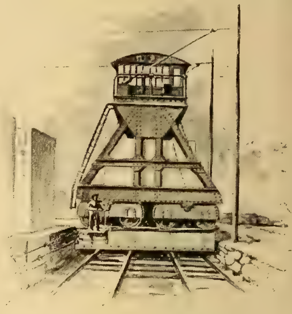
If imitation be sincere flattery,—not an inapt statement,—the makers of the Serve tube have recently been given good cause for self-congratulation, a device strikingly similar to that embodied in this tube having been introduced by an English firm for use in Lancashire and Cornish boilers with the same object. As described in one of the English journals, it consists of a series of angle irons, riveted longitudinally on the interior of furnace and flue tubes, and also externally on the boiler shell in the external flues, the object of these angle irons being to absorb additional heat from the hot gases flowing over them. A trial of a Cornish boiler so fitted up, is said to have been made a short time ago with quite remarkable results in point of efficiency.

Speaking of boiler tubes generally, it is interesting to note that they form one of the latest products of the at one time widely-described Mannesmann process by which tubing of various kinds is ingeniously rolled from solid bars of metal. It may not be amiss to repeat that the Mannesmann tubes depend upon the employment of what have been aptly called "skew-rolls," the billet forming the raw material of the tubing being introduced between several rolls which are set at angles to each other and also at angles to the billet. The rolls, being revolved, tend to give both a rotary and a translatory motion to the billet, and if this latter motion be prevented, as it is in the actual process, the surface metal of the billet will flow in the direction of the attempted axial movement, with the result of forming a hollow in the interior of the billet which emerges from the rolls in the shape of a seamless tube. Somewhat over a year ago the Royal

German Railroad Commissioners at Berlin began a series of careful tests of the physical properties of such tubes for locomotive work, and, on the strength of the results obtained, not only concluded to henceforth fit up all their new locomotives with these tubes, but are also said to have given heavy orders for Mannesmann tubes to be used for renewals. As a rather interesting and noteworthy novelty, recently introduced in the manufacture of the tubes, it may be stated that, while the tubes are of uniform outside diameter, they are made with the inside diameters varying from end to end, giving a tapering interior, and a consequently greater thickness of the tube walls at one end than at the other. Advantage is to be taken of this feature by placing the tube ends with the greater weight of metal toward the firebox end of the boiler where there is apt to be most wear. At the smokebox end, then, there would be less tube thickness, which, it is argued, would be conducive to a better utilization of the available heat of the cooler products of combustion.

THE remarkable development of electric power applications, which has formed so prominent a feature of engineering work during the past few years, is strikingly illustrated in connection with the harbor improvement now being carried out and partly completed at the important Spanish port of Bilbao. For years the mouth of the river Nervion, on which Bilbao is situated, has been impassable to vessels drawing more than about ten feet of water, on account of formidable sandbars, and it is the removal and subsequent prevention of these by the building of an elaborate jetty and breakwater system that has for some time claimed the attention of engineers. In prosecuting the work, electricity has been made use of most freely, serving admirably in the handling and transporting of the various structural materials employed, the working of drills, compressors and other apparatus, and in its more time-honored capacity of illuminating agent for facilitating night work. Probably one of the most interesting applications of electricity found there is shown in the small accompanying views of a 100-ton traveling crane, which is employed in transporting the huge concrete blocks used on the works. The crane not only raises its load by electrical means, but is also propelled by electricity, the current being taken from two overhead lines of wire through the intervention of the familiar trolley arrangement. Strictly speaking, the raising and lowering of the loads through the comparatively short distances necessary—only little more than sufficient to clear the ground—is accomplished by two hydraulic presses mounted on the main girder of the crane; but these presses are worked by electrically driven pumps, and the power for operating the latter as well as for propelling the crane is taken from one motor through suitable reduction gearing and friction clutches. The crane in its regular work is used to carry the blocks on to a transfer truck, which takes them to their final destination. This truck, shown in the second of the illustrations on this page, also is propelled electrically, and runs on four tracks, sufficiently lower than the track plane of the crane, to bring


A 100-TON ELECTRIC TRAVELING CRANE.


AN ELECTRIC TRANSFER TRUCK.

the latter in line with the upper surface of the truck. The electric current in this case, however, is taken, not from overhead lines, but from wires strung along the embankment at the side of the road bed, trolley wheels, as before, being employed to make electric contact between truck and wires. The whole installation is decidedly suggestive of some of the possibilities of electric power transmission in large engineering operations, and is in many respects unlike anything that has been previously done anywhere.

EVER since the first commercial application of electric storage batteries their use for street car propulsion has commended itself as representing probably the closest approach to an ideal traction method. The only important drawback to it has been the financial results of its operation. Renewed interest is, therefore, attached to what is now being done at New York with the Waddell-Entz battery system, which for more than six months has been in experimental use on a limited section of one of the street car lines, and so successfully that its extension has already been carried out in part and seems likely to be still further developed. With a six-car equipment, now in use, the expense for power, including everything properly belonging under that head, has been stated to amount to 9.32 cents per car mile, and while this, of course, appreciably exceeds the expense of the electric trolley system, a larger plant would naturally make the figures assume a much more favorable aspect. Reduced weight of battery, durability of plates and efficiency in the way of output are all claimed by the Waddell-Entz Company to have been brought by them to points never before attained, and while it is proper to make some allowance for a possibly too-enthusiastic view of the advantages of the system by its projectors, there still appears to be good reason to look forward to more encouraging results from it than have hitherto been obtained. Whether they will be sufficiently better to put the system on a fair level of competition with other traction methods now followed of course yet remains to be seen. The extension of the system as contemplated on the Second Avenue line at New York, however, ought to bring out data of definite value and do much toward fixing the commercial position of the method in street car service. The work promises to be carried along in a business-like way, with none of that spasmodic character which in most other experiments with storage battery street cars has been, in great part, responsible for inconclusive and unsatisfactory results.

THE power of electric search lights having more recently been made the subject of some comment, it may not be amiss to briefly recur to a few points in connection with it. Probably not one person among an average of a hundred has even an approximate conception of the illuminating power of one of these great centres of light, and it is only vaguely understood that it must be something enormous. As a matter of fact, with the projecting reflectors in use which serve as multiplying factors for the actual candle-power of the electric arc, the illuminating capacity of the beams issuing from one of the large modern search lights has been placed at the equivalent of something over two hundred million candles. Just what this means is not easily realized, though a popular measure of the lighting power

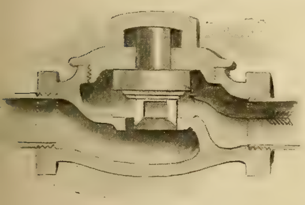
ONE OF THE SEARCH LIGHTS AT THE WORLD'S FAIR.

is afforded by the statement that, under favorable atmospheric conditions, one of these large lights can be seen nearly a hundred miles away and will illuminate objects at a distance of almost twenty miles with sufficient clearness to make their examination possible with the aid of a field glass. It is interesting to note in connection with this subject that more recently a rather novel application of a search light was made in Scotland. In order to enable workmen to labor through the night while a pit was being sunk, one of these lights, enclosed in a sheet iron case, was suspended over the mouth of the pit. Access to the lamp was obtained by a sliding shutter on each side of the case, and the light was adjusted by a screw on the top of the outside of the case. When desired the lamp could be adjusted so as to either diffuse light throughout the whole shaft or to concentrate it at the bottom. The arrangement illustrates simply one of many new uses to which the light promises to successfully lend itself.

The comments recently made in these pages on the burning of pulverized coal under boilers, with incidental reference to the cost of grinding coal to a fine powder, bring back to mind the ever-popular and closely allied subject of utilizing coal slack and of turning to good account the immense heaps of that material with which every one who has been in the anthracite mining regions is familiar. The matter has been harped upon for years, and every possible evidence has been given of the prevalence of the idea that these coal-dumps are veritable mines of good fuel and that all that is necessary is to shovel it on to cars and haul it to the ready market which the low price of the material would so easily command. It may not be amiss under the circumstances to direct attention to a few points which have been persistently overlooked by the enthusiastic advocates of this class of fuel. One of these is that a general use of the slack would most probably cause a decided increase in its price, and that it would be an easy enough thing for this price to rise quite beyond a paying figure. All experience tends to show that as soon as a real and substantial opening for the fuel would appear in the market, either in its original dust form, mixed with bituminous coal, or in the shape of molded lumps or briquettes in which it has been, and is still used to quite an extent, the price would go up, so that one of its chief advantages would be much diminished.

Another point is to be found in the quality of the slack. It is doubtful whether the great heaps as they now lie in the coal districts would be found as useful or as well worth buying at any price as some have thought them to be, largely made up, as they are, of slate refuse. No care was taken in past years to keep the purer coal separate from the strictly waste material, and the consequence is that the stuff not only burns poorly, but in some cases does not burn at all. Mr. Eckley B. Coxe, who can speak with a better knowledge of this whole subject than probably anybody else in the United States, in fact, remarked last month, in his presidential address before the American Society of Mechanical Engineers, from which an extract is given in this number, that the fuel value of the dust alone was *nil*, and that the slack must be mixed with a certain proportion of good coal before it can be put to satisfactory use as a steam raiser. Mr. Coxe also emphasized the very important fact that in all considerations of cheap coal the prospective user should try to ascertain not how many pounds of water will be evaporated by one pound of any coal in a given boiler, but how many pounds of water will be evaporated for one dollar. That is the vital point. Particulars of an actual case which recently came to hand illustrate its significance in a very striking manner, though the figures of cost would have to be somewhat modified to correctly reflect present conditions. Relatively speaking, however, they fairly represent what may be expected in other instances. It appears that a certain company burned coal screenings under their boilers, because they could get them for about two dollars a ton, and an important saving was confidently looked forward to, because previously five dollars a ton had been paid for coal, though the latter was of the best Lehigh lump variety. When the coal bills, however, were gone over after a short trial period it was found that something like three tons of the screenings were being burnt under the boilers in order to raise the same amount of steam formerly obtained from one ton of the five-dollar Lehigh coal. Evidently there was no economy in this, and the use of the cheap coal was disappointedly abandoned.

BOILER accidents at first sight sometimes appear to embody elements of the mysterious, but careful examination into all the details of any case rarely fails to satisfactorily explain why something happened. A case in point, of more than usual interest, is cited in a recent issue of The Locomotive, published by the Hartford Steam Boiler Inspection and Insurance Company. An urgent call to visit an electric power station had been received by one of the company's inspectors. The plant had a battery of six boilers which had been working satisfactorily for some time until suddenly, without warning, the first three of them were seen to rapidly lose their water. The feed pump was started at once, and the water rose in the second and third boilers, but the first one still showed none. Prompt hauling of the fires prevented damage from being done, and, on the arrival of the inspector, an examination was made. The feed pipe was found in place, and the end of it was perfectly free. All openings to outside attachments were also free. The bonnet on the blow-off valve was removed, but no defect was found. Finally, the cap on the check valve in the feed pipe, between the stop-valve and the boiler, was taken off. This check valve is shown herewith. When raised, it fitted snugly in the bonnet so that no pressure could come on top of the valve to force it downward. With pressure in the pipe, the flow could, therefore, readily change from feeding the boiler to emptying it, the flow of water holding the valve open instead of closing it. As no defect was found in the blow-off pipe connections, or elsewhere, it was believed that the check valve on the feed pipe did act in this manner, under the peculiar conditions presently to be mentioned, and that it was the cause of the accident. The feed water was pumped into a live steam purifier, fitted with shelves, and from the purifier it fell into the boilers by gravity. The purifier became full of water and began to back water through its live steam supply pipe into the main steam pipe, so that it became necessary, to blow it off, to drain it to the proper level. The live steam supply to the purifier was stopped by shutting off that end of the main steam pipe, so that the pressure in the purifier fell below the 115 pounds boiler pressure. As this pressure gradually decreased, the blow-off valve on the purifier being open, the pressure in the boiler forced the water in the boiler back through the feed pipe, its check valve refusing to act, and out through the purifier blow-off. If the pressure had not been shut off the purifier, the accident would not have happened; also, if the internal feed pipes had not been run down to within a few inches of the lower sheet, so much water would not have been backed out of the boiler.



A TROUBLESOME CHECK VALVE.

TRADE catalogue making in America, if not elsewhere, has gradually become a fine art. For years American catalogues have been the admiration of foreigners, and yet a comparatively small number of these catalogues were printed on particularly fine paper or had special attention paid to typography. There were a few firms only that indulged in the luxury of what might be termed "gilt-edged" catalogues, and single editions of these frequently cost a small fortune. Within the past eight or ten years, however, the aim at really artistic productions in this line has become widespread, and where, as intimated, there were formerly a dozen or two firms there are now scores of them who issue trade publications in which the paper, engraving, typography and cover are all of such a high order of excellence as to challenge attention. Aside from this there is another point, though rather more utilitarian in aspect, which is worthy of note, and that is that the classifications and descriptions in these catalogues are generally sufficiently definite to enable the exact quality, price and style to be found either by name or number and an order to be made out, with the certainty of being satisfied, even when the prospective purchaser has never seen the goods. The possible performances of the tools and other apparatus are detailed, the different grades are illustrated, and, as far as possible, it is made easy for the buyer to get a good general knowledge of everything that the manufacturer includes among his products. In this respect, as in that of artistic excellence, American catalogues are, generally speaking, vastly superior to those of English or European origin, in which there is but too often an inadequateness of description which leaves one unpleasantly in doubt as to the quality or performance of any particular tool advertised.

UNDOUBTEDLY the most elaborate of all American catalogues for several years past has been the mammoth production of the firm of Manning, Maxwell & Moore, of New York, devoted to railroad and machinists' tools and supplies, and the new edition for 1894, which has just been issued, shows probably still more painstaking preparation and execution than had been spent on their earlier volumes. Altogether, the book comprises 1103 imperial quarto pages and nearly 6000 illustrations, and the binding is in keeping with a work so complete and costly. There seems to be nothing in the lines to which it is devoted that cannot be found treated of in its pages both comprehensively and intelligently. The descriptions of the various appliances are necessarily brief, but none the less clear, and the illustrations are as helpful to a better understanding of the features of the tools as the engravers' art has been able to make them. But the book must be seen and examined in order to be properly appreciated. Such mention of it as can be here made can do it but scant justice.

IN this connection the rather unique production coming from the Jones & Lamson Machine Company, of Springfield, Vt., also deserves mention. The immediately striking feature of the little book is found in its cover, which shows a deeply embossed reproduction of one of the company's turret lathes, clean cut and surprisingly well worked out in detail. How admirably the work was executed may be appreciated from the fact that the bas-relief cover page had been taken by an interested recipient of the catalogue as a pattern from which a brass casting was obtained which faithfully reproduced every little detail present in the original. The casting was shown at the recent meeting of the American Society of Mechanical Engineers and was the subject of much interested comment.

Henry Darcy

CASSIER'S MAGAZINE.

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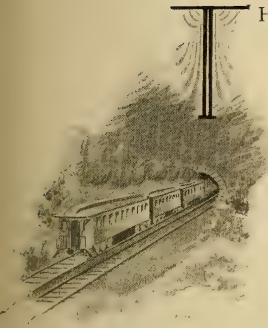
TWO GREAT RAILROAD EXHIBITS AT CHICAGO.

By John C. Trautwine, Jr., C. E.

(Concluded from page 191.)



THE Baltimore & Ohio Railroad Company had set for itself the herculean task of illustrating the evolution and development of "The World's Railway," and that upon so grand a scale that it is entirely within bounds to say that nothing of its kind, approaching it in magnitude or in completeness, had ever been consummated or even attempted. The exhibit covered a floor space of 36,000 and a wall space of about 14,000 square feet, and was claimed to be the largest exhibit in the World's Fair.

The plan of this unique exhibit was conceived, and most admirably carried into execution, by Major J. G. Pangborn, Exposition Executive, and formerly Assistant General Passenger Agent for the Company, and in this work he was ably seconded by Mr. Ransom C. Wright, Mechanical Expert, under whose intelligent care the writer had the pleasure of spending a most interesting day in making a tour of the exhibit. It consisted chiefly of two great collections,—a Museum of Locomotives and a Gallery of Illustrations.

By far the most striking feature of the locomotive exhibit was the truly colossal array of actual engines and of full-size reproductions, beginning with Newton's idea of a relief-pressure locomotive, and ending with two enormous engines, passenger and freight respectively, built for the Company by the Baldwin Locomotive Works during the past year. This unexampled collection contained no less than fifty-four specimens of locomotive engines, embracing the greatest variety of design, and every one was either an actual engine which had been in use (and many of them might be used to-day) or a full-size reproduction, capable of being moved so as to show the interaction of its parts. The reproductions were built up, for the most part, of wooden boards covered on both sides with canvas, and the results were counterfeits, calculated to deceive even the very elect.

The space occupied by the company upon the floor of the Transportation Building Annex measured about 80 by 475 feet, and the first fifty-two of the specimens were arranged in three rows, each occupying nearly the entire length of 475 feet, while a fourth row com-

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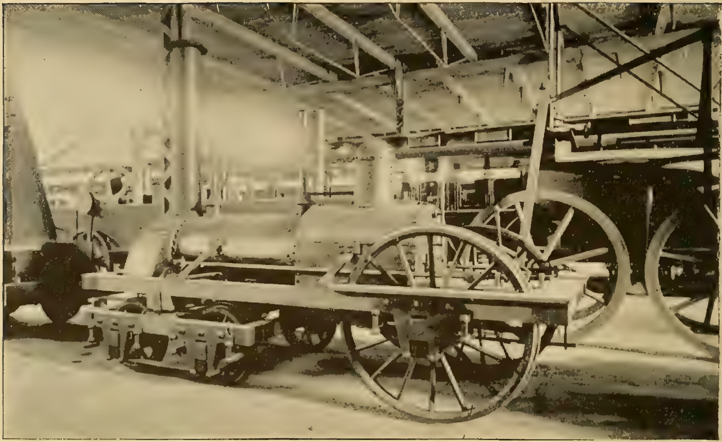
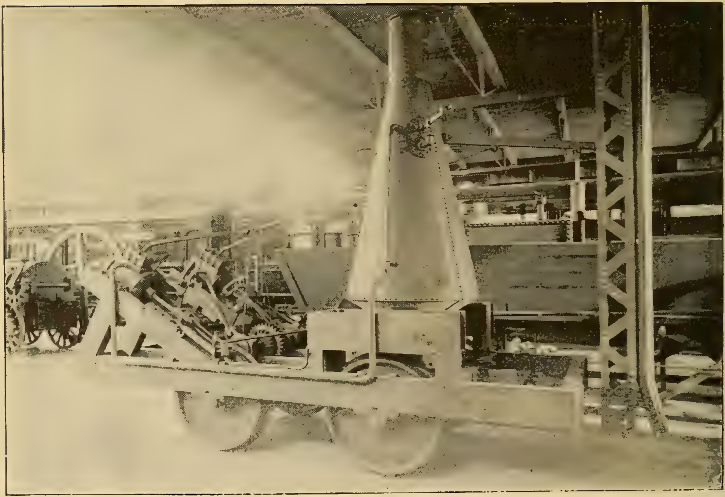
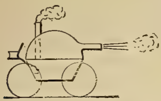


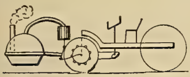
THE EXPERIMENT, 1832.

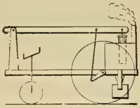


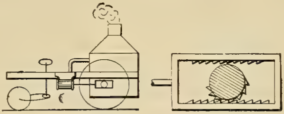
THE JAMES II., 1832.

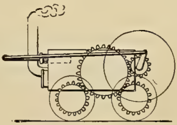
prised the two modern locomotives referred to, and two of the company's standard Royal Blue Line passenger coaches. Justice cannot be done to this remarkable collection without at least briefly noticing each of its items.


THE NEWTON, 1680.


THE CUGNOT, 1769.


THE MURDOCH, 1784.


THE READ, 1791.


THE TREVITHICK, 1800.

In the first row there was, to begin with, the "Newton,"* of 1680, which represented an embodiment of Newton's idea of propulsion by means of the relief pressure obtained by allowing a jet of steam to escape backward from the boiler. This, so far as known, was the first suggestion for steam travel on land. The label upon this first object in the Museum bore the significant remark,—"The world was the same in the seventeenth century as now in the nineteenth, and there were those who laughed incredulously at Newton in 1600 as only a few years ago there were those who laughed at Edison." Next in order came the "Cugnot" dating back to 1769. This engine was originally designed and constructed by Nicholas Cugnot of the French army and was used for transporting artillery. The original is now preserved in the Conservatoire des Arts et Métiers at Paris. There were in this engine two vertical, single-acting cylinders which communicated with each other by levers, and acted upon the front wheel by means of a circular rack arrangement. The front wheel carried the entire weight of the boiler and was used for steering the craft which, being built before the days of railroads, was used upon common roads. Owing to the smallness of the boiler the engine could run only a short time without stopping. The "Murdoch," of 1784, of which a reproduction from a model was shown, is still in existence. It was built by Wm. Murdoch, who was Watt's assistant, and, as Watt was opposed to the high pressure system, Murdoch was compelled to do his experimenting in the night watches. The engine had only one cylinder and the piston acted upon the single pair of driving wheels through an overhead beam. As in the "Newton" and the "Cugnot," the single front wheel was used for steering. The upright, cylindrical boiler was heated by a spirit lamp. Further along was the engine designed and patented in 1791 by Nathan Read, of Salem, Mass., the inventor of the multi-tubular boiler. This engine had two horizontal cylinders which acted upon the driving axle by means of a rectangular frame attached to the piston rod and containing a double rack which

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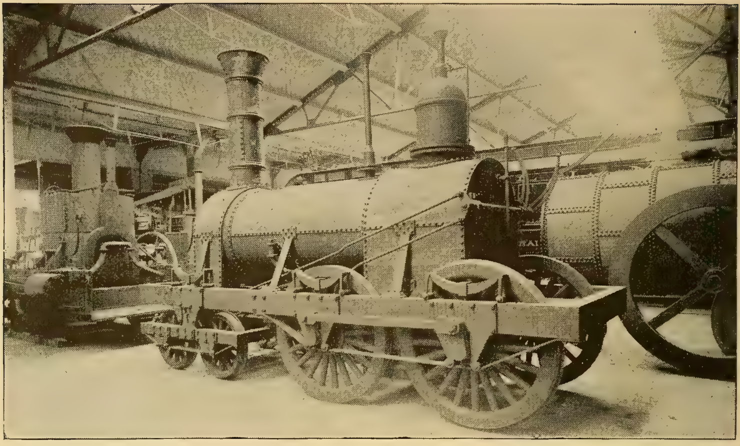
* The outline cuts shown of some of the more striking of the engines are from extremely crude sketches made upon the spot, and are not drawn to scale, but are to be taken merely as indicating, in a very general way, the relative positions of some of the more prominent parts. They are reprinted by kind permission of The Railroad Gazette.



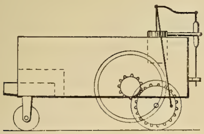
THE CAMPBELL, 1837.

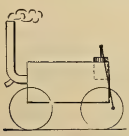
engaged with a semi-pinion upon the axle.

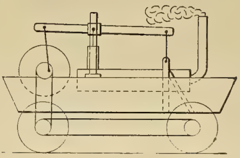
Richard Trevithick's various early engines were represented by a number of models, one of them dating back to 1800, of which the original is still preserved in the South Kensington Museum. This engine had one vertical cylinder placed within the boiler and was provided with a fly-wheel. The water in the boiler was heated by hot iron bars, placed in what otherwise would have been the fire-box. A later engine, labeled "The first locomotive on rails in the world," was used on the Merthyr Tydvil tramway in South Wales. It had a horizontal cylinder acting upon the driving wheels by means of gearing. Some of the three-foot cast-iron, edge rails and the rough stone blocks to which they were attached were shown, as were also two of the four-wheeled iron cars which were drawn by the engine. Another one of Trevithick's engines, bearing the pretentious name "Catch Me Who Can," was shown in the same group. This had a single vertical cylinder placed in the boiler and worked, without gearing, upon a single pair of drivers. The exhaust steam, after being used to heat the feed water, was discharged into the smoke stack.

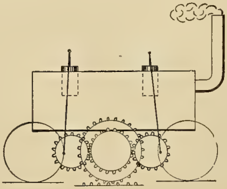
One of the most interesting of the several engines on exhibition was the remarkable machine built and operated at Philadelphia in 1804, by Oliver Evans, and known as the "Oruktor Amphibolis." Evans ran the machine through the streets of Philadelphia from his shop at 9th and Market streets to the Schuylkill river, where it took to the water, being, in fact, very much like a wooden boat on wheels. Being provided with a paddle wheel at the stern, it proceeded down the Schuylkill to its mouth, thence up the Delaware river in which it was used for dredging. It had a single vertical cylinder with an overhead beam and was provided with rope gearing. The boiler was horizontal, built up in brick work. The "Blenkinsop," further along, was built in 1811 by Mathew Murray and John Blenkinsop, both of England. It had two double-acting vertical cylinders placed tandem fashion upon and within the boiler. The connecting rods were attached to two spur wheels, gearing into a pinion which engaged with a single rack rail, laid outside of the track. The engine weighed about five tons and was capable of hauling ninety tons on a level at a speed of three and one-half miles an hour, and fifteen tons up a grade of about 1 in 15.

The "Mechanical Traveler," or "Horse Leg Locomotive," designed and built in 1813 by Wm. Brunton, of England, was also reproduced there. This was the oft-pictured machine that pushed itself along by means of its hind legs, after the manner of a grasshopper, or of a boy sitting on a tail board of a toy cart. It had flanged wheels which ran upon rails. Then again there was a reproduction of the model of an engine built by William Hedley of England in 1812, Hedley's aim being to determine the possibility of driving an engine by means of the adhesion of smooth wheels upon smooth rails. The machine was loaded so as to obtain a weight corresponding to that of the engine, and was driven by men who walked alongside and turned cranks, which latter acted, through gearing, upon the two pairs of driving wheels. The original is still shown in the South Kensington Museum. Another one of Hedley's engines, known as the "Puffing Billy," was shown in the same group. It was built in 1813, and was designed to put to practical test the results of his experiments. This engine, of which the original also is to be seen in the South Kensington Museum, had a return flue boiler and two vertical cylinders, one on each side of the boiler. The reproduction of George Stephenson's first engine, the "Blucher," of 1814, had been prepared from data furnished by Messrs. Robert Stephenson & Co., Limited, of Newcastle-upon-Tyne, and a reproduction also was shown of another Stephenson engine which had been remodeled in 1828 by Marc Seguin of Paris. This latter had two vertical cylinders, and forced draft was produced by a blower, placed on the tender and driven by a belt from one of the tender axles. The original engine is preserved in the Conservatoire des Arts et Métiers. The "first locomotive patented in America" was claimed to be the "Howard," designed in 1829 by Wm. Howard, of Baltimore. This engine, which was described and illustrated in the Journal of the Franklin Institute at the time, had two vertical cylinders with a walking beam. The wheels were loose on the axles and were driven by ratchets, and the front axle was pivoted to facilitate the passage of curves.

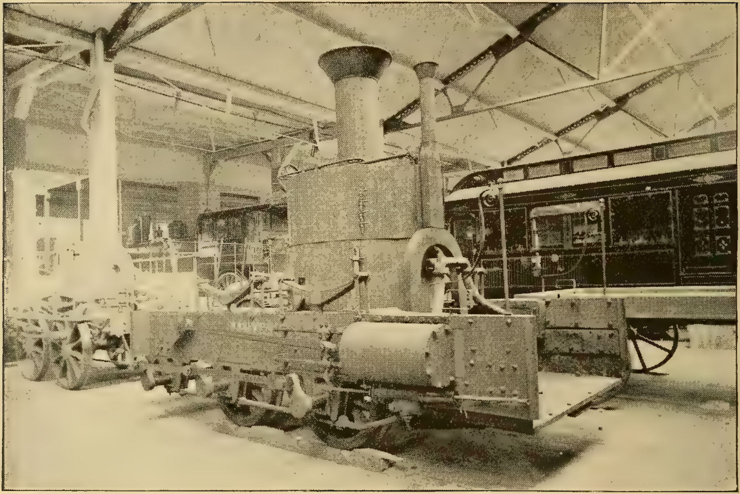

TREVITHICK'S LATER ENGINE.


THE CATCH ME WHO CAN.


THE ORUKTOR AMPHIBOLIS, 1804.

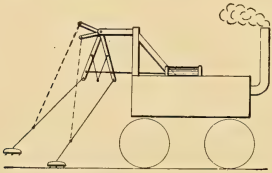

THE BLENKINSOP, 1811.

The remaining engines in this row were the historical "Rocket;" the "Sans Pareil," of 1829, built by Timothy Hackworth, of England; the

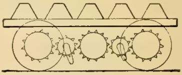


THE MAZEPPA, 1837.

"Novelty," of 1829, designed and built by Braithwaite and Ericsson, in which there were two vertical cylinders acting upon a pair of drivers by means of a bell crank; and the "Stourbridge Lion," of 1829, which was designed and built by Foster and Rastrick of England. This was "the first actual locomotive seen in America," having been bought by Horatio Allen for the Carbondale Road, at Honesdale, Pa.

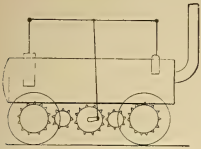


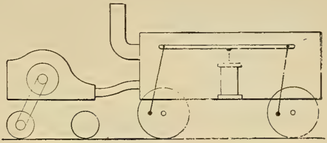
THE MECHANICAL TRAVELER, 1813.

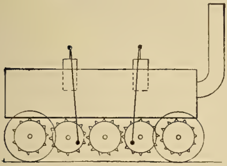


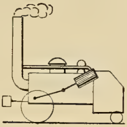
HEDLEY'S ENGINE, 1812.

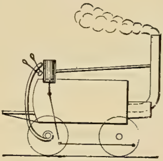
Passing along to the second row, we find the "Tom Thumb," of 1829, built by Peter Cooper and labeled as "the first locomotive built and the first to draw a car on the American continent." This engine made its first trip on the Baltimore & Ohio Railroad from Baltimore to Ellicott City. Then there were Stephenson's "Mercury," of 1830, typical of the modern British engine; and the "Best Friend," "the first locomotive built for actual service in America." The latter was turned out at the West Point Foundry for the South Carolina Railroad. Next in order came five engines which competed in the Baltimore & Ohio Railroad trial in 1831 and none of which resembled any then known foreign engines. They comprised an engine built by George W. Johnson, "the first in the world with a double fire-box;" the "York," which was the prize engine, built by Davis & Gardner, of York, Pa., and in which there were two vertical cylinders, one on each side, acting downward through connecting rods upon the centre of a horizontal beam which joined the cranks on the two drivers; an engine built by Stacey Costello, of Philadelphia, in 1831, having a Galloway boiler and two oscillating cylinders; an engine by Ezra Child, of Philadelphia, "believed to be the only rotary locomotive ever successfully used on rails;" and the "James I.," built by Wm. T. James, of New York. This engine was used, for a time, upon the Baltimore & Ohio Road, but in an evil hour it ran upon and killed the son of its builder, whereupon the latter withdrew it from service. It had two gears for different speeds and something looking very like a link-motion. The "York" was subsequently remodeled by Ross Winans, who removed the horizontal beam and substituted a connecting rod acting through gearing upon the driving axle.

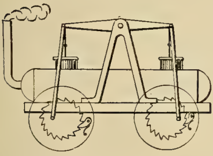

THE PUFFING BILLY, 1813.

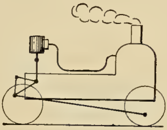

SEGUIN'S ENGINE, 1828.

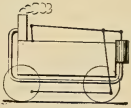

THE BLUCHER, 1814.

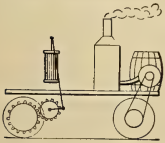

THE ROCKET.

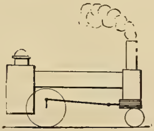

THE SANS PAREIL, 1829.

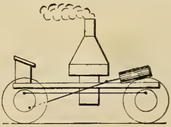

THE HOWARD, 1829


THE NOVELTY, 1829.

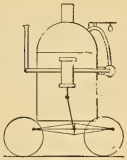

THE STOURBRIDGE LION, 1829.


THE TOM THUMB, 1829.

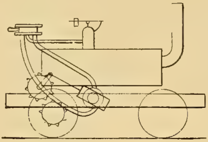

THE MERCURY, 1830.


THE BEST FRIEND.

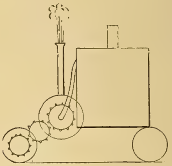
The first actual engine seen in the collection was the "Atlantic," which is of a grass-hopper type and the "oldest American locomotive in existence." After 60 years of constant service on the Baltimore & Ohio Road it was taken off duty early last year and then, strange to say, not because of unfitness for further service, but solely in order to prepare it for the trip to Chicago for exhibition at the Fair. This preparation included the removal of the cab and tank and the parallel rods connecting the drivers, all of which had been added subsequently to its construction. Close by the "Atlantic" was a reproduction of the "Old Iron Sides," M. W. Baldwin's first engine, built in 1832. This had been built, on Stephenson's "Planet" type, for the Philadelphia, Germantown & Norristown Railroad. Next to this was a reproduction of the "South Carolina," designed in 1832 by Horatio Allen, and built at the West Point Foundry. It was labeled as the "first eight-wheeled engine in the world," "the first locomotive in the world with a horizontal double boiler, and father of the Fairlie type, so largely used in Europe." Next came the "Experiment" of 1832, designed and built by J. B. Jervis, of New York, "the first locomotive in the world with the bogie or forward truck." Going on further we find the "James II.," said to be the "first locomotive in the world with the link-motion;" the "Traveler," known originally as the "Indian Chief," an engine of the grass-hopper type which had been running from 1833 up to last year; and the "Jefferson," also a grass-hopper engine, which was taken directly from work on the Baltimore & Ohio Road for the purpose of exhibition and which reached Chicago "with ashes on grate and in pan, and water in boiler." Following these, came the engine designed by Henry R. Campbell, of Philadelphia, in 1837, represented as "the first American eight-wheeled locomotive;" the "Mazeppa," of 1836, a grass-hopper engine with horizontal cylinders, the original of which had been in service for fifty years; the "Hercules," of 1837, built by Eastwick & Harrison, of Philadelphia, and claimed to be "the first locomotive in the world with equalizing levers;" and the "Lafayette," built in 1837 by Wm. Norris, of Philadelphia, and claiming the distinction of



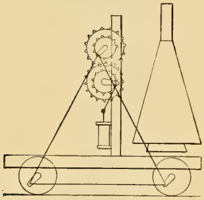
THE YORK I.



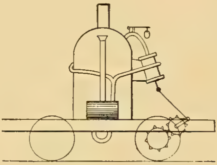
COSTELLO'S ENGINE, 1831.



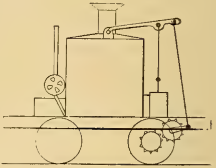
CHILD'S ENGINE.



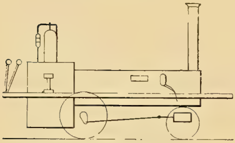
THE JAMES I.



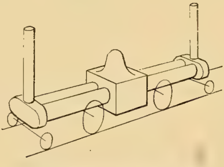
THE YORK II.



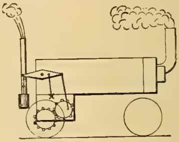
THE ATLANTIC, 1830.



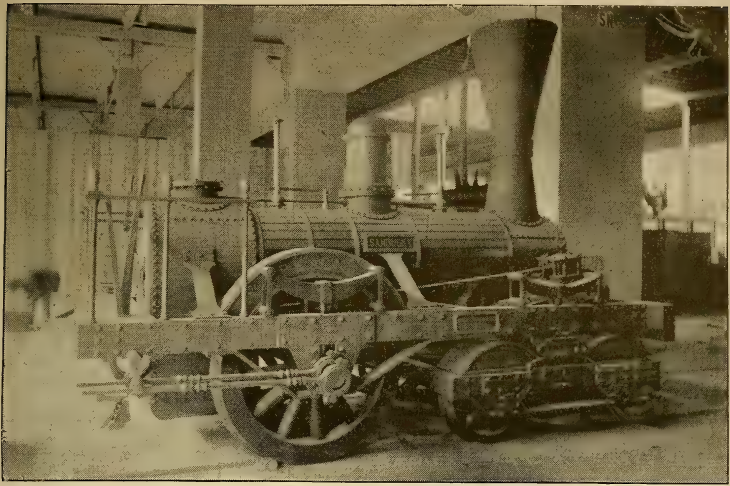
THE OLD IRONSIDES, 1832.



THE SOUTH CAROLINA, 1832.



GEO. W. JOHNSON'S ENGINE.

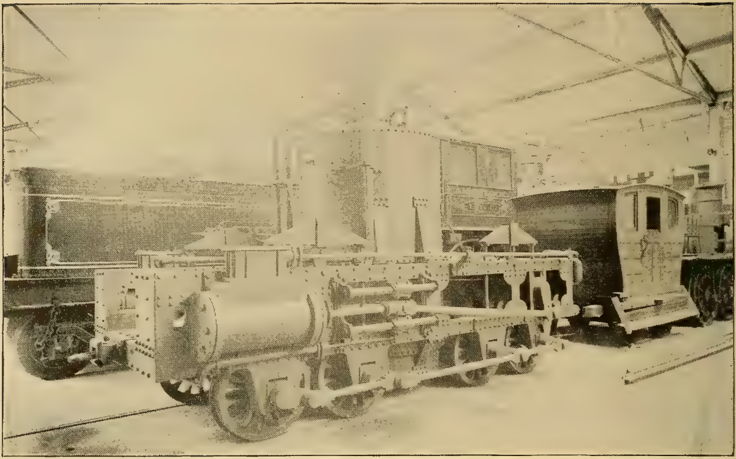


THE SANDUSKY, 1837.

being "the first six-wheeled engine on the Baltimore & Ohio."

The first engine in the third row was a reproduction of the "Sandusky," built by Thomas Rogers, of Paterson, N. J., in 1837, and which was the "first locomotive to run west of the Ohio river," and also "the first American counterbalanced locomotive." The driving wheel rims were hollow except in the part opposite the cranks. Next to this was the original "Rocket," of 1838, "the first engine on the Philadelphia & Reading Railroad." By the side of this was the "Samson," of 1838, a battle-scarred veteran, rescued at the last moment from the scrap heap. This engine had been shipped to Nova Scotia in 1839, and was used in the coal mine traffic there up to 1882. It has two vertical cylinders, and the engineer and fireman were at opposite ends of the engine. Each was provided with a bucket of sand, to be thrown on the track by hand, when required. Behind the "Samson" was an old English "railway carriage" which came over from England with it. In this there were only two seats, facing, respectively, backward and forward, and each holding about four persons. Following these relics came the "Albion," the "Buffalo," the "Mt. Clare," and the "Dragon." The "Albion," which was in use for 40 years, had neither tender nor cab, and a bucket hung in front of the smoke stack to hold pine knots which served as a head-light. The "Buffalo," which was built in 1884 by Ross Winans, was "the first eight-wheel coupled locomotive in the world." It had a vertical boiler and small wheels, bringing the cranks close to the ground, and earning for the type the name of "Mud-Digger." The "Dragon," built by M. W. Baldwin in 1848 for the Baltimore & Ohio, to burn Cumberland coal, has eight drivers coupled. It was returned to service on the Baltimore & Ohio Road after the close of the Fair.

There was also a reproduction ot "the first camel-back," built in 1848, with eight 43-inch drivers, and "the first locomotive of the ten wheel camel type," dating back to 1852. The "Mason," of 1853, was the original

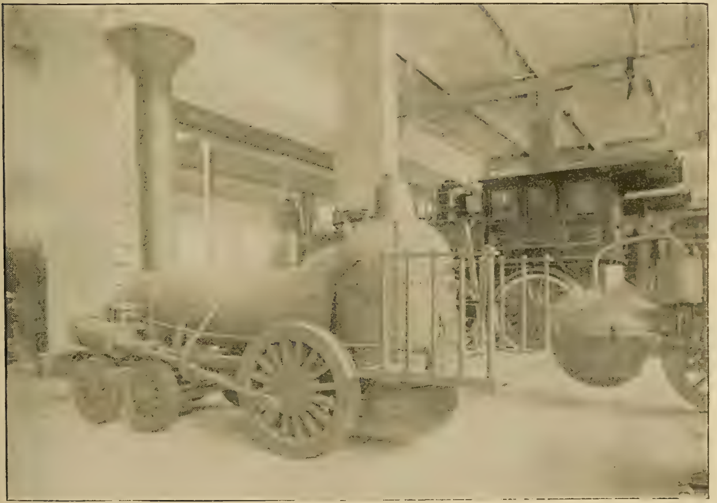


THE BUFFALO, 1844.

engine in its original form, and was a fine example of the highly-colored type in fashion in the fifties. Special interest attached to the "Peppersauce," "the first mountain climber in the world," designed by Sylvester Marsh, and built in 1863 by the Whitten Machine Company, of Boston, for the Mt. Washington Railway, on which it ran for ten years or more. What was shown was "the original old engine, standing upon a section of the original old track." The boiler is vertical and is suspended from trunnions. Then came the "Perkins," designed by Thacher Perkins, of Baltimore, and built at the Mt. Clare shops of the Baltimore & Ohio Railroad in 1863. This was the "first of the type of heavy ten-wheel locomotives built especially for passenger service on mountain divisions." The last engine in the row was the "Baltimore & Ohio 600," the "first passenger Mogul," built by the Baltimore & Ohio Railroad in 1876, and exhibited at the Centennial Exhibition at Philadelphia.

The fourth row began with a specimen of the standard type of the company's eight-wheel passenger locomotives, built by the Baldwins in 1893, from designs by G. B. Hazlehurst, General Superintendent of Motive Power of the road. This is a simple engine. Next to it was the "Director General," 1893, representing the standard type of the company's eight-wheel passenger engine with Vauclain compound cylinders, also built by the Baldwin Works, and designed for service on the Royal Blue Line between New York and Washington. There was shown there also a ten-wheel engine, exhibited by the Baldwin Works, and built for freight service on the Baltimore & Ohio Road. Two vestibule coaches of the Royal Blue Line were also on exhibition, one of them being a combination car with baggage and mail compartment at one end, and the other a passenger coach with a smoking compartment.

While the Museum of Locomotives impressed every visitor by its great dimensions and by the physical actuality of its specimens, the Gallery of Illustrations was scarcely less remarkable for its extent, and the great number of objects contained in it rendered it, of course, far more complete than the other could possibly be. All of the objects in the Museum were pictured with a fidelity and an artistic skill that rendered a study of the gallery a most absorbing one. Most of the pictures, too, and especially the very large and fine collection, specially prepared by the company itself for this exhibit, were of most liberal dimensions, so that even a hasty glance at the collection could not fail to be of the greatest interest and to convey a vast amount of useful information. About seventeen hundred pictures were exhibited. In some extent, the advantages of a strictly logical and chronological arrangement, but a very valuable and instructive series of drawings prepared by Mr. Theodore Cooper, of New York, and representing the evolution and development of the American railroad bridge, had been crowded out of the exhibit proper and placed in the gallery of the main Transportation Building, while some six hundred views, including a series of photographs of Baltimore and vicinity, contributed by Mr. Cummings, of that city, were not exhibited at all.



THE LAFAYETTE, 1837.

this gallery was represented, to use Major Pangborn's words, "every country where the locomotive whistle has been heard."

Some idea of the extent of this portion of the exhibit may be formed from the fact that notwithstanding that the company had been awarded some 14,000 square feet of wall space, this allowance proved all too small. Not only had it been found necessary to arrange the pictures so as to economize space to the utmost, sacrificing, to

The Gallery of Illustrations may be divided into the following principal groups: A.—A series of eighty-seven wash drawings representing the "evolution" of the locomotive. B.—A series of one hundred and thirteen similar drawings, dealing with its "development," and beginning when locomotives first drew trains on public railroads. C.—A series of one hundred and thirty-six wash drawings showing the development of permanent way. D.—A collection of drawings, already referred to, contributed by Mr. Theodore Cooper, of New York, and representing the development of the American railroad bridge. E.—Seven maps of the United States, showing the development of the railroad system of the country by decades. F.—Twenty-four bromide photographs, presented by Messrs. Neilson & Co., of the Hyde Park Locomotive Works, Scotland, representing various types of modern locomotives manufactured by that firm. G.—Seventy-seven large and very fine bromide enlargements direct on canvas, retouched by Mr. Thomas Moran, representing the "Picturesque B. & O." H.—A series of twenty-nine wash drawings, illustrating the development of the power brake. J.—A bewildering array of ancient and modern maps, drawings, lithographs and photographs of railroads, locomotives, cars, bridges, stations, etc.

Groups A and B naturally comprised chiefly a reproduction on paper of the full-size objects displayed in the Museum of Locomotives, but the artist, by peopling these objects with the living persons who were supposed to operate them or to be carried by them, had given to them there an added charm which even a full-size working reproduction fails to convey; and many engines were there pictured which the limits of the "Museum" necessarily forbade placing there. Here were shown the "sail cars" used, or at least tried, upon the Baltimore & Ohio in 1829, and upon the South Carolina in 1830. Some remarkable devices are shown as belonging to the "hand-power period." The "Steam Carriage Period," a little further on, presented a varied array of more or less grotesque and pretentious vehicles, provided with less or more practical arrangements for steam locomotion. Among public conveyances under this head comes Hancock's London omnibus of 1833, curiously named the "Autopsy," which ran, or was to run, between Paddington, Regent's Park and the city.

Among the objects shown here, and not included in the museum, the writer noted, specially, a contrivance working upon the principle ot the recently proposed and miscalled "unicycle," which latter consists of a very large rolling cylinder, within which works a machine operated like the ordinary bicycle. The weight of the latter, kept by its rider always in advance of the point where the cylinder touches the ground, constantly urges the whole system forward, and, it is claimed, with enormous capabilities in the matter of speed. In its steam prototype designed by David Gordon, of England, in 1822, and shown at Chicago, the cylinder is geared on the inside, and the inner vehicle, being correspondingly geared, acts upon it positively and not by friction as in the case of the "unicycle." Inside the inner ring sits the engineer, very black and grimy, and looking the picture of crushed dejection, while his lords and masters, sitting upon a forward truck pushed by the cylinder, ride up aloft.

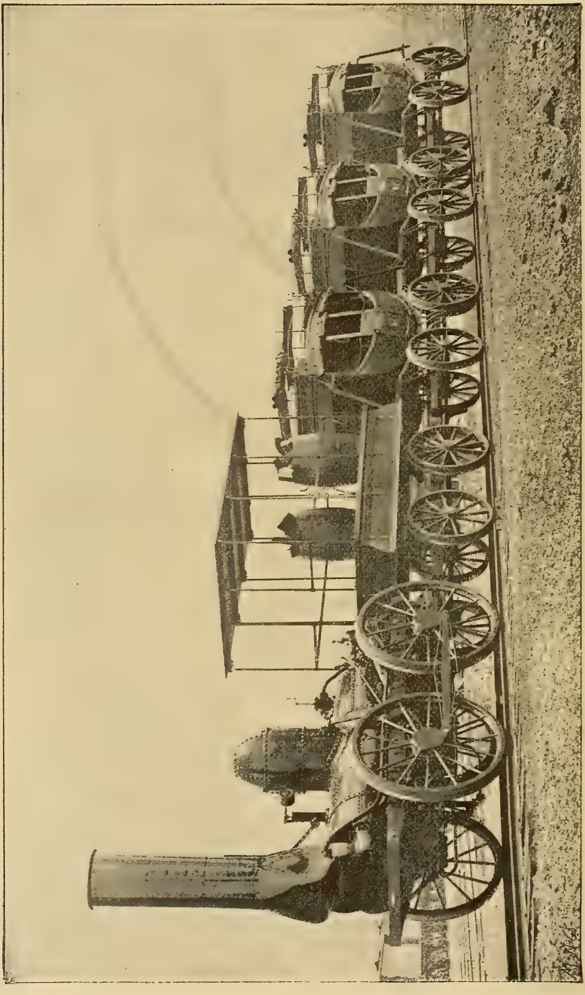
Among other engines not represented in the Museum of Locomotives were Stephenson's "Twin Sisters," of 1827, "the first double-boiler locomotive," each of the vertical, bucket-shaped boilers having its own smoke stack; Stephenson's "America," the first locomotive ordered abroad for America; and Foster & Rastrick's "Angenoria," of 1829, sister engine to the "Stourbridge Lion," which latter is said to have been the first to arrive here and be put upon rails. The array of "firsts" in these collections, by the way, was calculated to bewilder the student, and it was refreshing to find, once in a while, a locomotive that was not "first" in some respect. The commonest question asked by one's fellow-spectators, and one of the hardest to answer, was, "which is the oldest engine?" The writer gives the claims as he found them, placing them in quotation marks, and must refer the skeptical reader to Major Pangborn and Mr. Wright.

Group B, devoted to the development of the locomotive, began with Stephenson's "Mercury." There was the "DeWitt Clinton," turned out from the West Point Foundry in 1831; Stephenson's "Patentee," of 1833, with the first steam brake; J. & C. Carmichael's "Earl of Airlie," of 1833, with its large bell-cranks; Norris' "Washington," that astonished everybody by climbing the 1:14 inclined plane at Philadelphia on the smooth rails; Eastwick & Harrison's "Gowan and Marx," of 1840; Escol Sellers' centre-rail engine, of 1847, with two pairs of cylinders, one for the ordinary drivers, and one for the pair of wheels gripping the centre-rail; Norris' "Lightning," of 1849, "the first American locomotive with wrought iron wheels;" Blavier's (French) engine, of 1855, with two pairs of very large drivers; James Millholland's twelve-driver-coupled, of 1857, for hauling the Reading's coal trains between Port Richmond and Falls of Schuylkill, Philadelphia; Haswell's "Duplex," of 1861, with one pair of drivers and two high-pressure cylinders to each driver; the original "Consolidation," designed by Alex. Mitchell and built at Baldwin's in 1866; the first Decapods, the "Ant" and the "Bee," built at Lancaster in 1867; the first Wootten, of 1877; and compounds by Von Borries of Germany, by Mallet of France, by Webb of England, and by the Schenectady, Brooks, Rogers and Baldwin Works of America, including Baldwin's Wootten compound, of 1891, weighing 197,000 pounds, "the heaviest locomotive ever built."

The series, beginning with the earliest and crudest forms, and leading up through more and more nearly perfect types, found its culmination in the compound engine designed by Mr. Wright, Mechanical Superintendent of the Exhibit. The moral is obvious. Mr. Wright had used a high and a low pressure cylinder on each side, in order to have his engine perfectly symmetrical, and had placed his high-pressure cylinder directly over the low-pressure cylinder; but, departing from Mr. Vauclain's practice, he placed a very considerable distance between the two cylinders, and used a vertical walking beam, seeking thereby "to have each cylinder deliver its work without undue friction between the two," and thus to obviate the necessity for excessive dimensions in the piston rods. The engine, thus far, exists on paper only.

A design involving a rack rail in an underground conduit with which the car communicated through a slot, was dated 1824, and a bona fide cable road was attributed to Saxton, of England, under date of 1833. Harrison's (English) "Hurricane," dated 1837, but looking much more recent, showed a strange lack of acquaintance with the laws of friction. The designer, in order to get a "hurricane" speed, used a pair of very large drivers, but put them out behind his boiler and engine, where they got no weight but their own.

Group C, of wash drawings, representing the development of permanent way and track, began with the wooden stringers used in France in the seventeenth century, and led down (or up) to the various forms of track with metal ties or sleepers now in use. It showed, among other things, as did the Haarmann exhibit, that mitred joints are a bit of relatively very ancient history. Group D, composed of the large drawings of bridges, contributed by Mr. Theodore Cooper, occupied three standing frames, 32 feet long by 8 feet high. The collection was one of great value, and its preparation must have involved a large amount of labor upon the part of its contributor. There were a few prints, but most of the objects were drawings, or heliographs from such. The collection included the old Trenton bridge, built by Theodore Burr in 1804, and reconstructed in 1848 and 1869; the Baltimore & Ohio Railroad bridge at Harper's Ferry, designed by B. H. Latrobe, and built by Lewis Wernwag in 1836; the Howe truss over the Connecticut at Springfield, Mass., built by William Howe in 1838; the Pennsylvania Railroad bridge over the Susquehanna river at Rockville, Pa., J. Edgar Thompson, chief engineer, 1848–9; the Erie Railway bridge over the east branch of the Susquehanna, Julius W. Adams, resident engineer, 1849; the McCallum truss at Lanesboro, on the Erie, 1851; the old and new Portage Viaducts; the Columbia



THE "DE WITT CLINTON," ON THE NEW YORK CENTRAL RAILROAD, 1831.

Bridge (Burr truss) over the Schuylkill, Philadelphia, 1832; Long's truss bridges of 1833 and 1837; the earliest boiler plate girder bridge, as originally erected on the Baltimore & Susquehanna Railroad, now the Northern Central Railway, designed and erected by James Millholland in 1846–7; the standard iron Howe truss bridges of the Boston & Providence, built about 1849; the Brandywine Creek Bridge of the Erie, designed and built by Squire Whipple in 1848; Town's lattice over the Hudson at Troy, 1851; the great Cascade Glen wooden arch on the Erie, designed by Julius W. Adams, 1848; the Niagara Suspension bridge, Roebling, 1852–3; the Victoria Tubular bridge, Montreal, 1854–9; the Bollman bridge of the Baltimore & Ohio at Harper's Ferry, 1852; Fink bridges on the Baltimore & Ohio; the first Post truss bridge, at South Washingtonville, N. Y., built by S. S. Post in 1865; the channel span of the Steubenville bridge, designed by J. H. Linville, built 1863–4; the New York Central double-track, riveted lattice bridge over the Erie Canal at Canastota, N. Y., as originally built; C. Shaler Smith's Kentucky River cantilever bridge, 1876-7; Mr. Morison's recent Alton, Bellefontaine, Memphis and Cairo bridges; the Kinzua Viaduct; the Pecos River Viaduct, Phœnix Bridge Company, 1891; and many others.

Of peculiar interest was Group E, showing, in its seven maps, the history, by decades, of the development of the railroad system of the United States. Beginning with a scarcely noticeable nucleus in the extreme east in 1830, confined to a very few short lines in New York, New Jersey, Pennsylvania, Maryland, Virginia and South Carolina, the network gradually expanded until, in 1860, we find the northeastern section of the country, close up to the Mississippi river, pretty highly charged with the new element. Then, in 1870, a great spark flashed out, and striking westward, reached the Pacific coast in one bold zig-zag leap. After this, the discharge from the eastern cloud became more and more nearly continuous, until, in 1890, the whole western half of the country was covered with a network of the red lines denoting the path of the rail. The later numbers of this series indicated a remarkably symmetrical division of the country into four sections of approximately equal extent; the northeastern section very much more densely covered than any of the others, and the other three (southeastern, northwestern, and southwestern) much less fully occupied and differing less in "intensity" among each other.

Series F, of twenty-four bromide enlargements, presented by Messrs. Neilson & Company of the Hyde Park Locomotive Works, of Scotland, was a magnificent collection of views of modern British engines. Group G formed a remarkably beautiful collection. The pictures were quite large, some of them measuring about 6 x 30 feet. They were therefore hung above those of the other series, but were nevertheless very clearly seen. The series began with a view of the beach of Lake Michigan at Chicago, and ended with the Statue of Liberty in New York harbor. Among the largest and most striking views of the series were those of Pittsburgh, Washington, Harper's Ferry, the summit of the Alleghenies at Buckhorn Wall, Locust Point at Baltimore, and Fairport on Lake Erie. Group H, representing the evolution and development of the power brake, began with forms applied in England to ordinary carts upon common roads in 1630, including one where the man in charge, walking or standing alongside, inserted a "sprag" (stick) between the spokes of the wheel, indicating the cheapness of labor in those days, and included Stephenson's first locomotive steam brake, of 1833, applied to the drivers. It worked by means of a toggle joint, and was placed on one side of the engine only. In the Creamer spring brake, of 1853, a cord, pulled by the engineer on the locomotive, released a coil spring wound on the spindle of the hand brake. The apparatus thus constituted, in effect, an artificial brakeman. The Loughridge, of 1855, was a chain brake, extending under the train and controlled from the engine. The series concluded with the modern forms of brake of the Westinghouse, American and Smith companies.

Group J contained drawings by John B. Jervis, Henry R. Campbell, J. Snowden Bell, Ransom C. Wright (of 1856 and 1858), Hobart Brown, Horatio Allen and M. N. Forney (of 1857 and 1861); and quite a number of very interesting drawings by the late Mr. George Whitney, contributed by his brother, Mr. John R. Whitney, of A. Whitney & Sons, car wheel makers, of Philadelphia. There were also drawings bearing the stamp of Robert Stephenson & Co., Limited, one of them showing the first link-motion constructed by Stephenson ten years later, it is claimed, than the appearance of that device in America. One of the most interesting, and certainly one of the most beautiful, of the objects in Series J was a large oil painting by Edward L. Henry, of New York, painted during the past year, and representing a scene connected with the opening of the Mohawk & Hudson Railroad in 1831. The tiny old "De Witt Clinton," with its miniature train* filled with curious and expectant passengers, is about to start from a way station, and the natives have assembled to have a look at the new-fangled contrivance. There is the skeptic, of advanced years, listening, with impatient incredulity, to the arguments of his younger and believing friend; and the village boys curiously inspect the engine, while among them stands the young swell, who seems to consider it beneath his dignity to manifest more than a languid interest in the proceedings. The conductor, with his horn, is hurrying forward to give some order to the engineer, who is looking after his fire. The picture strikingly illustrates the character of the relation that must then have existed between the new means of travel and the old. The neighborhood of the stopping place is thronged with vehicles, the occupants of which seem to feel that they know all there is to the subject of land travel, and look down upon the interloper as a bird of passage, soon to demonstrate its incapacity and to relapse into the oblivion from which it had so lately sprung.

Besides the Museum of Locomotives and the Gallery of Illustrations, the exhibit contained a few miscellaneous objects of great interest. Among these were a fine sample of the company's old strap rail, trenailed to longitudinal stone sleepers, laid touching, and the set of tools that were used for laying the corner stones of the Baltimore & Ohio Railroad and of the Washington Monument. These tools were recovered, practically, from the scrap heap.

It is most gratifying to be assured that it is the intention of the Baltimore & Ohio Company to preserve this magnificent exhibit in permanent form, probably in a museum in Baltimore, specially devoted to the purpose. It would be inconceivable that it should be otherwise, that it could be contemplated to allow this wonderful series of reproductions to be reduced to kindling wood and the actual engines relegated to the scrap heap, whence some of them were rescued, and the Gallery of Illustrations to be stowed away in the oblivion of an attic. The exhibit was a great object lesson, and, as such, it is of the highest importance that it should remain in compact and easily accessible form. It will be of even greater interest in future World's Fairs, affording, as it then will, a means of noting the progress made in the art in the mean time.

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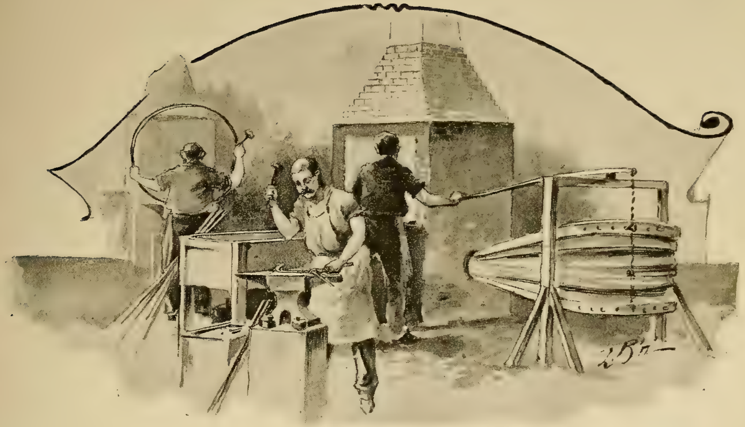
* The Clinton and train together were reproduced in the New York Central exhibit, side by side with its fast modern No. 999, and a train of three modern cars.



THE EARLY METALLURGY OF FRANCE.

By Pierre Mahler, of the Ecole des Mines, Paris; and B. H. Thwaite, London.

EVEN yet, after the lapse of eighty years, Napoleon the First, this great figure in battle history, is clothed with the glamor of fame, his name possesses a great and fascinating interest to all students of history and will, like those of the classic Greek heroes, live to the end of time. When we compare the conditions of industry and their immediate relationship to the means and manner of the materials of war of the present era with the conditions of manufacture in England and of the countries of the British allies, who were drawn into the vortex of deadly conflict for the supremacy of Europe at the time immediately preceding the Napoleonic wars, the wonder is, that this great Corsican strategist could in his own country obtain all the bolts of Vulcan that his armies threw against the serried ranks of his allied foes; but when the real position of the applied metallurgic science of France at this time, or immediately preceding the first revolution, is adequately understood, we not only see the real explanation of the success of the victorious armies of France, but realize the contemporary superiority of French metallurgic science over that of the other great European powers.

The Moniteur of July 12th, 1792, in its "Nouvelles Militaires," gave the strength of the combined army of Napoleon as numbering three hundred thousand men. Comparing the population of France then and now this figure is formidable and alone proves that the "armèe Française" was the first in numerical strength in the world. The field of artillery, equipped by the famous Gribeauval, was absolutely without rival, whether measured by quality of workmanship, the calibre dimensions, or number of pieces. The navy com-

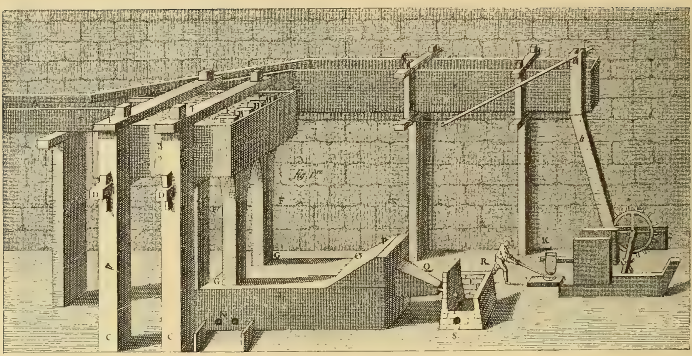


FIG. 2.—A CATALAN FORGE.

prised 250 vessels, and was little inferior either in tonnage, weight or number of guns to that of the English.

The French administration had bitterly learnt the lesson that the times of peace should be utilized by the preparation of the materials of war. The royal arsenals and ship yards consequently were always actively employed and the armory was never short of weapons nor ammunition. This constant activity cultivated the arts of metallurgy, and the latter attained in France a relatively high degree of perfection, when it is understood that the dynamic power of steam had not even been realized, and that Papin's and Watt's invention had not yet been applied to metallurgic processes. The mechanical ingenuity of the arrangements for producing blasts of air, for hammering and for rolling down and conveying masses of metal call forth our ready admiration. Thanks to the Academie des Sciences, there was published in Paris in 1761 a magnificent work, entitled "Descriptions des Arts et Metiers," by which we are enabled to clearly see, without much additional word painting, scenes of metallurgic industry that permit us to understand the early methods of manufacture. The illustrations accompanying this paper are from actual electros of the originals, and are themselves admirable examples of the contemporary condition in France of the art of pictorial illustration.

The metallurgists of France banded themselves together into trade guilds or corporations. They divided their technical industrial art into two divisions or classes, one of which was concerned with the recovery of the ore from its earthy associates, while the other considered the manipulative treatment of the metal, so that the first class comprised the furnace men, the founders and forge men, and the second class comprised the armorers, the gunsmiths, the locksmiths and braziers. The artistic work of the second class was of a high order of excellence, and there is an abundance of exquisite examples of their beautiful art still to be seen in France. With such artistic ancestors it is befitting that in France should now be the cradle of contemporary art in

FIG. 1.—THE BANNER OF A METALLURGIC GUILD.

Europe. Among the most ancient of the corporation and trade guilds of the artisans of the industry, represented by the second class of metal workers, was that of Brisude, which included under its banner the handicraft of ornamental gold work. The banner of this ancient metallurgic guild is shown in Fig. 1. Eloi, the chosen patron saint of this craft, proves the age of the corporation as dating from the fifteenth century. The method adopted by the craft for extracting the ferrous metal from its oxygen or earthy associate was known as the Catalan process, which is described as follows :

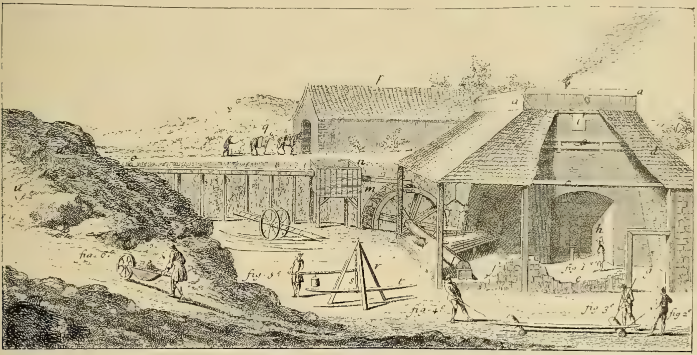


FIG. 3.—A FRENCH BLAST FURNACE OF THE EIGHTEENTH CENTURY.

The ore (iron oxide and earth) was placed in a small furnace hearth along with charcoal and a blast of air was applied. The foreign or earthy associates separated from the metal in a fluid mass, known in metallurgic parlance as slag, while the oxygen was assimilated by the carbon of the charcoal, leaving the pure metal in grains, submerged below the fluid slag. The latter was run off from the aggregate mass of granular metal which, in ball form, was drawn under the tilt hammer where the component parts were compressed by powerful blows into a compact form. The process was not unlike the ancient Hindustanee method, but in the latter dried leaves replaced the charcoal. It has been in active operation in France, but in gradual decreasing proportion, up to within a quite recent period.

The last Catalan forge, working at Capoulet, Ariege, had its fires extinguished six or seven years ago, terminating an honorable record of work of nearly 400 years. The process followed in the Catalan forge is really a miniature, and no doubt the origin, of that which is now employed for the extraction of the metal from the ore in our immense blast furnaces, with this exceptional characteristic, that in the modern blast furnace process the heat is of such an intensity that the metal, as well as the slag, is rendered fluid, the fusibility of the former being increased by the addition of limestone. A brief description of the operations involved in the modern blast furnace will, therefore, be interesting, and will enable a close comparison to be drawn between it and the Catalan method.

The iron ore, after being first dried, is charged into the mouth of the cupola-shaped and lofty furnace, its elevation being effected by hydraulic, pneumatic, electric, or mechanical means. Alternately, or along with the ore, masses of charcoal, coke, or coal and limestone are tipped into the furnace, and as the materials gravitate to the base of the

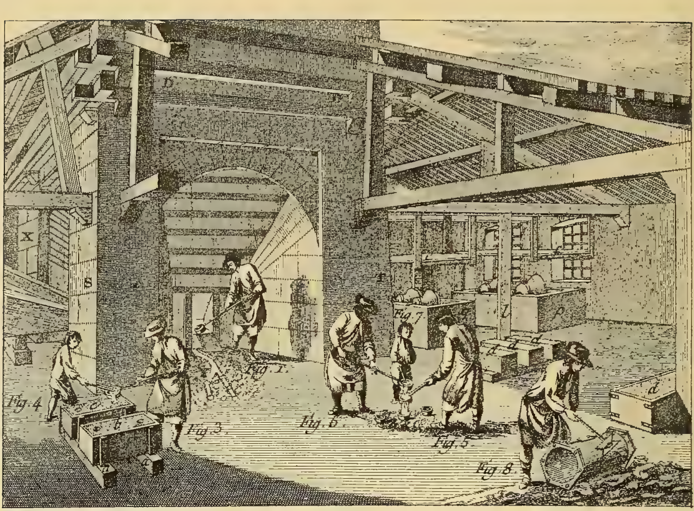


FIG. 4.—A BLAST FURNACE ANNEX.

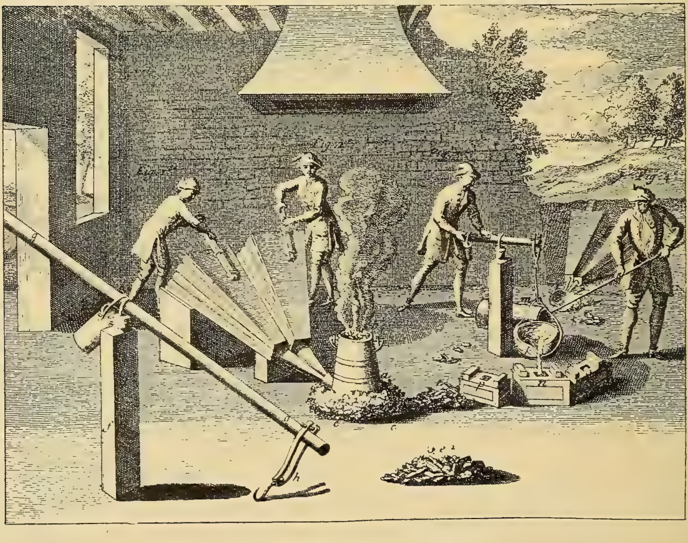


FIG. 5.—AN OLD FRENCH IRON FOUNDRY.

column, some fifty feet in height, zones of increasing temperature are traversed until the absolute base is reached, known as the hearth. There the heat is so intense that the iron is melted. This fierce heat is obtained by blasts of air provided by powerful blowing engines, associated with the fuel, and under the influence of the intense temperatures the oxygen leaves the iron ore and combines with the carbon of the fuel, while the earthy matter associates itself with the limestone to form the fluid mass, known as slag, which rapidly percolates through the mass to the hearth level, where it floats on the surface of the fluid metal. Carbon is partially absorbed from the fuel by the iron and lowers the fusing point of the latter, enabling the metal to become more fluid and to more rapidly descend to the hearth ; finally, when sufficient metal has accumulated there it is allowed to issue from the furnace in streams to form elongated bars—the pig-iron of commerce.

In this form it is available for the iron founder for producing castings direct, but a greater proportion is treated by secondary and even tertiary processes for the purpose of further purification and to render it fit for wider industrial uses. The older method of further purification was known as refining, and the plant for permitting this operation to be performed was named the refinery. The method of refining adopted, was the expulsion or elimination of the impurities by exposing the metallic mass in a more or less fluid condition to contact with the atmosphere. The iron was melted in the hearth of a small furnace and then subjected to a blast of air from a tuyere. This plant and method is known as the German refinery and refining process, and even to-day a similiar method is in every-day use in Sweden and Austria.

This early process is not, however, so economical as that known as the Comtois process, because the waste of iron involved in the operation is of serious proportions. In the Comtois process the iron is melted on the hearth of a reverberatory furnace and the impurities are simply oxidized by the flame coming from the furnace grate. This process—the parent of the English puddling process—is still carried on in many iron works in Staffordshire, England, but is destined to be crowded out by the more economical method generally adopted for producing mild steel.

In the Comtois process the workmen, by means of iron tools, work up the fused materials so as to expose them to the action of the gases of combustion. By this means the materials are partially oxidized and slightly carbonized. In the English puddling furnace practice cast-iron is melted on the hearth of the furnace, and is exposed to the oxidizing action of combustion by being thoroughly worked up. The small proportion of carbon is oxidized out, leaving the pure iron in a plastic state. The metal, in this condition, is worked into a ball-shaped mass, which is then carried to the steam hammer and is afterward rolled into small bars, known as billets.

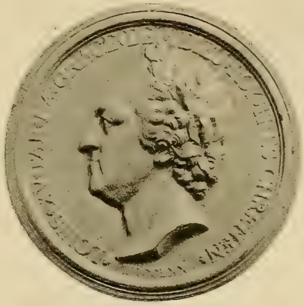


FIG. 6.—A CAST-IRON MEDALLION OF LOUIS XV.

By means of these methods iron was produced in France, from comparatively early periods and prior to 1789. Compared, however, with what are known as the pneumatic and open hearth processes, these ancient methods were slow, costly and uncertain. In the pneumatic process, perfected by Bessemer, the cast-iron is melted in a cupola, from which it is run out into a vessel known as a converter, in which it is subjected to a powerful blast of air, which traverses the molten metal. In its passage the carbon is entirely burnt out, but is afterward added in proportions necessary to constitute steel. This addition of the precise proportion of carbon was only possible by the use of this element associated with manganese, which has a greater affinity for oxygen than has carbon, so that, on its addition to the metal, the short final blast, subsequently applied, does not burn out the added carbon, but merely oxidizes the manganese. The entire process of converting or refining iron pneumatically, and adding the requisite carbon to form steel, occupies some thirty minutes.

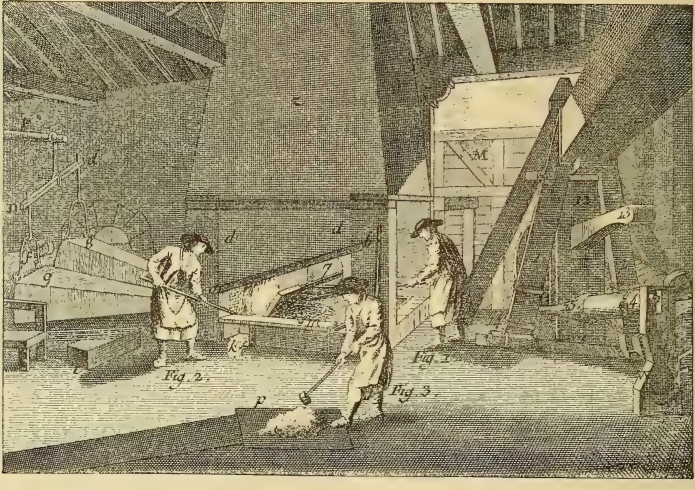


FIG. 7.—AN OLD-TIME REFINING FORGE.

The open hearth process is really a development, by two Frenchmen, named Martin, of the early method of refining already described. A mixture of wrought and cast-iron is placed on the hearth of a reverberatory, gas-fired furnace, in which a very high degree of heat is attainable. The wrought iron is turned into a pasty mass, gradually absorbs a proportion of the carbon from the molten cast-iron, consequently becomes more fusible, and eventually amalgamates with the whole of the metal, the general proportions of carbon being reduced by dilution and by oxidation, the latter resulting from the flow of an oxidizing gas flame over the surface of the metal. When the carbon is entirely eliminated, a mixture of iron and carbon is added in the form of an alloy, known as ferro-manganese, by which the exact proportion of carbon is supplied to the metal to produce the desired quality of steel. This is run into a merchantable form. The process involves a greater expenditure of time than the pneumatic method, the time necessary varying from seven to twelve hours.

Before the French Revolution, the iron manufacturing industries were fairly distributed throughout the Kingdom of France. All this is now changed. The altered processes absorb enormous masses of ore and combustible, and have compelled the establishment of works, in either the coal or the iron ore fields. Hitherto the average grade of

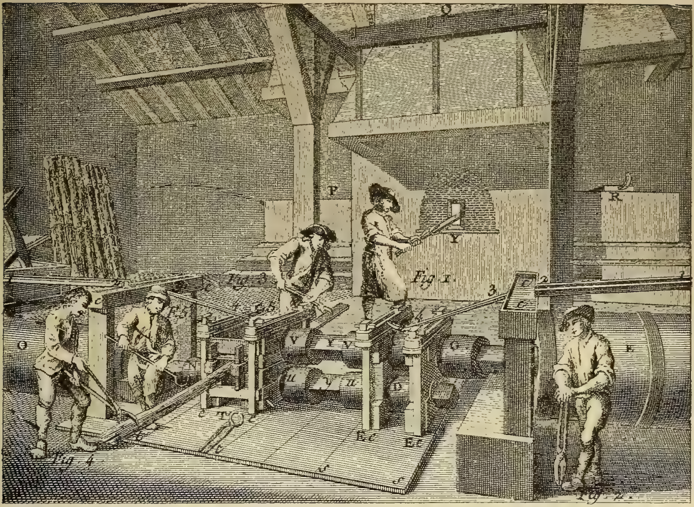


FIG. 8.—AN EARLY FRENCH ROLLING MILL.

ores, which are well distributed throughout France, sufficed to feed for many years the small iron works. Coal was rarely used, resource being invariably had to charcoal, which, thanks to the splendid forestry and woodland facilities of France, was both plentiful and cheap. A country possessing the raw materials of average metallic value, along with adequate sources of water power to work the rolling mills and tilting hammers had, obviously, the ideal requirements for the establishment of extraction and forge works.

Several regions were particularly favored in this respect, for instance, Lorraine, Franche-Comte, Normandy, Bretagne and Champagne, but especially those of Berry and Le Nivernais. These two last named provinces alone had, in the time of Louis XVI., more than thirty forges, along with blast furnaces. The numerous ancient manufactories, established and endorsed by the government before the date of the French Revolution, aided very considerably in the development of the metallurgic art. Even to-day several of these establishments are in active operation, among them the forges of La Chaussade (Nievre), the works at Ruel, the iron manufactories of Saint Etienne, founded in the year 1516, and the Indret foundry. The last, just before the revolution, was engaged in the manufacture of bronze cannon.

A few years before the great revolution several industrial companies were established, among them the famous Creusot works. The direct, or Catalan, method of producing metallic iron from the ore, was especially practiced in the Pyrenees, on the outskirts of Rancie, the deposits of ore having been worked by the neighboring communes as far back as the Middle Ages, and prior to the year 1293. This antique example of an iron ore mine and iron works has survived even to the present day. In the island of Corsica several Catalan forges were also established. Fig. 2 is an interesting view of one of them. The small furnace O is clearly shown. The method by which the air blast was furnished is ingenious. Water flows along a con-

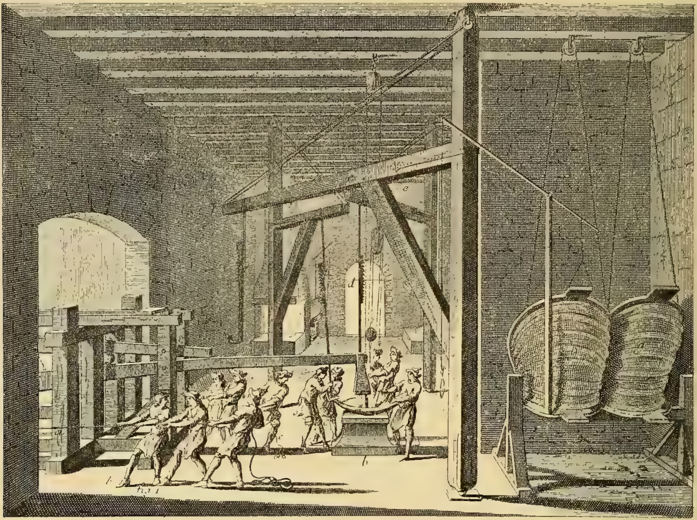


FIG. 9.—FORGING AN ANCHOR A HUNDRED YEARS AGO.

duit into a vessel E, surmounting two hollow trunks F, cone-shaped at their upper ends. The water flows in at the sides of these inverted cones, and the air is drawn into the trunk and carried to the base, where it escapes into G, from which, at considerable pressure, it enters the tuyeres of the furnace.

Fig. 3 is a general view of a French type of blast furnace of the eighteenth century. This furnace, like most of the furnaces and cupolas of that time, received its air blast from gigantic bellows, actuated by a water-wheel in a way similar to that adopted for operating tilt hammers. Stout prongs projected from the axle of the water-wheel, and came into contact with the bellows, pressing them down to a certain extent, after which they were released and brought back to their original position by counter balance weights. The method by which the lengths of iron, as run from the furnace were broken, is interesting. It will also be seen that the furnace was placed at such an elevation that the ore and fuel could be delivered to the mouth of the furnace direct without special hoisting apparatus.

Fig. 4 represents the interior of an iron foundry with the artisans busy at work. This foundry is clearly an annex to a blast furnace. One of the workmen is shown obtaining a ladle full of the metal; others are engaged in pouring the metal into molds, while a youthful assistant is clearing away the slag. Another is clearing a casting from the sand. Grinding wheels mounted on trough-like frames are shown in one corner of the building.

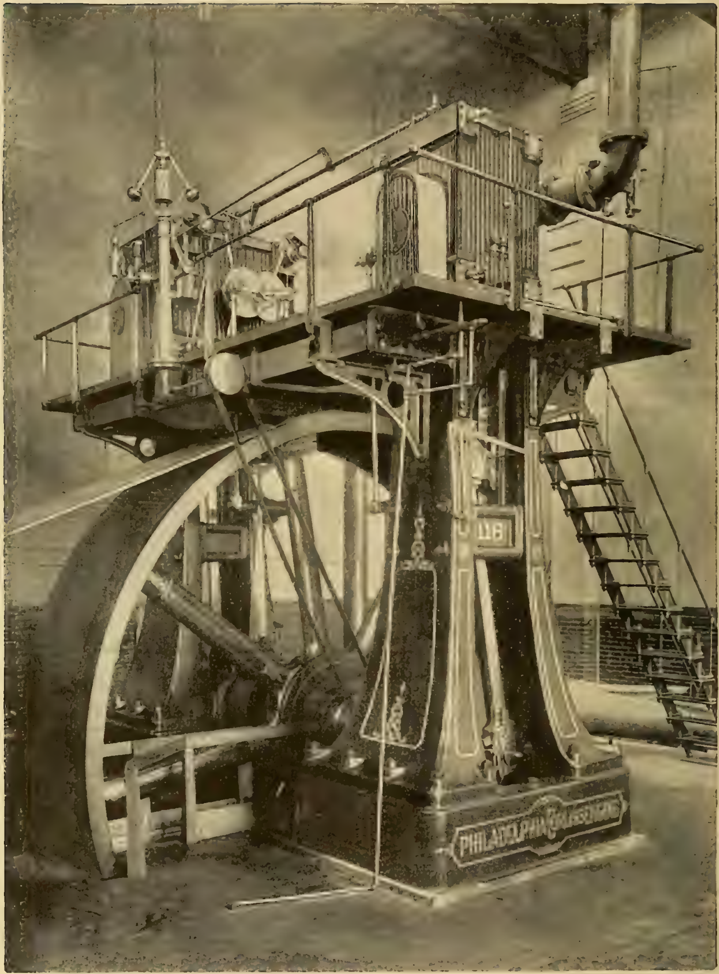
Distinct from this type of foundry in which the metal is run direct from the blast furnace, is that shown in Fig. 5. A small hand-blown furnace is there utilized for melting broken pieces of iron. These furnaces were capable of melting one hundred weight of metal at one time. When heavier castings were required, several cupolas were worked simultaneously. To-day it is not uncommon to run castings of 100 tons in weight by the simultaneous employment of several cupolas.

The molders, designers and pattern-makers attached to these small early French foundries were very often artists of the highest excellence ; in fact, it may be asserted that the artistic delicacy of their fine castings has never been surpassed. Fig. 6 is a photogravure of a medallion of the effigy of that luxurious monarch, Louis XV., cast in iron in the last century, lost and recently discovered near Nevers. This beautiful casting is proof positive that the French artisans were worthy emulators of those celebrated founders of Berlin, whose remarkable productions in cast-iron excite the wonder and admiration of connoisseurs of to-day.

In Fig. 7 we see the representation of the interior of a refining forge, in which, by the Comtois furnace, the iron was freed from its impurities. The spongy mass of iron is made into a ball and then removed to a floor plate, on which it is hammered to remove the slag and other impurities. The principle of operation is partially that of the puddling and Bessemer processes of to-day. On the right hand side of the illustration we notice the hammer, in which the ball of metallic iron was beaten, power being furnished by a water-wheel, shown in the rear.

Formerly the making of anchors was undoubtedly the most important work of the heavy forge. What an amount of manual labor was involved in the preparation in these articles of trust and security, which even in those days attained a weight of a ton each ! The work of these anchors, upon which depended the safety of the French fleets, was absolutely irreproachable, and there is no evidence before us that any vessel of Nelson's worthy foes was lost from failure of an anchor due to bad forging. Fig. 9 is a most interesting view, showing the famous forge of Rochefort during the actual operation of the forging of an anchor. Even at that time the power of the hammers for dealing with those large instruments of navigation was considerable. The hammer-head of the manual tilt forge hammer shown weighed about 700 pounds. Compared with the modern 100-ton steam hammer at Woolwich, and at Creusot, and the enormous hydraulic presses at present in use, these early hammers, however, are mere toys.

No record of human progress is brighter nor more encouraging than that included in the arts of metallurgy. To metallurgy we owe the locomotive and the railroad, the ocean liners that have practically destroyed distance between brotherhoods divided by oceans deep, and the steam engine, which has added to the wealth and happiness of cultivated nations. Metallurgy has, alas, added to the horrors of warfare, by creating monsters in steel, belching forth projectiles deadlier than ever. These warlike offsprings of the brain, however, were never anticipated by the pacific inventors who have developed the metallurgic industry.



VERTICAL CORLISS, CROSS COMPOUND, CONDENSING ENGINE, BUILT BY THE PHILADELPHIA ENGINEERING WORKS, PHILADELPHIA, PA.

SOME RECENT STEAM ENGINE DESIGNS.

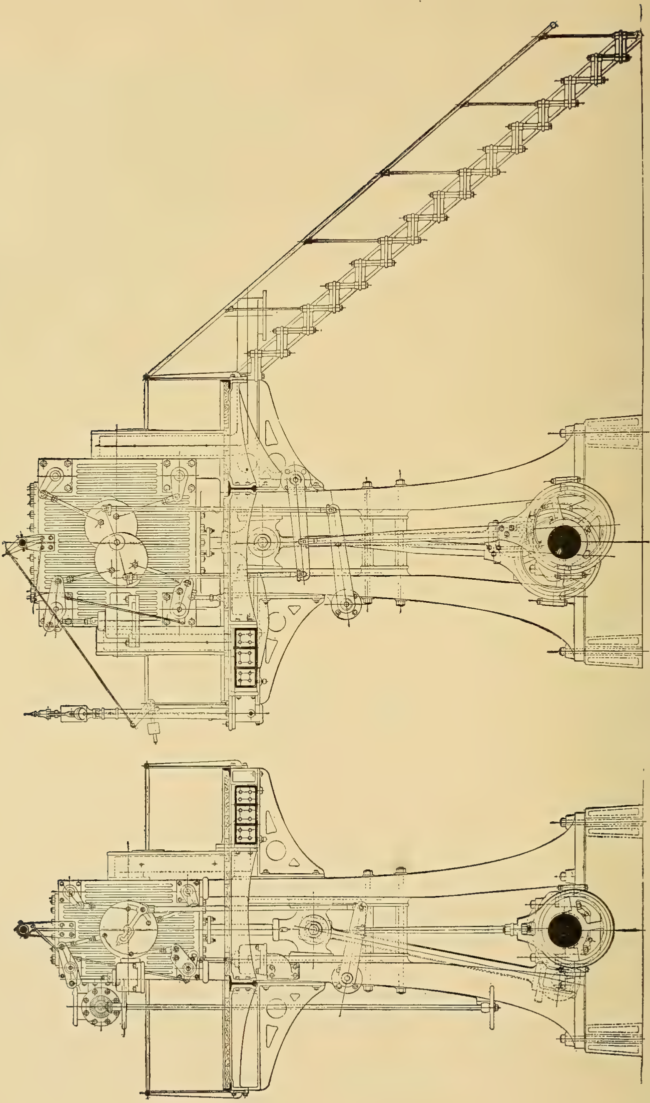
By Geo. L. Clark.

NEW steam engine designs, even though they embrace nothing of the distinctly revolutionary kind, always appeal to some extent to the designing and constructing steam engineer, showing, if nothing more, what other engineers in the same field are doing, and indicating, in a degree, what measure of success has attended their particular efforts. Good and bad features in such designs may be studied with equal profit; both teach lessons of interest and value, and may be turned to good account in the prosecution of other work of a similar nature. No special explanation is, therefore, needed for the illustrations of the several engines shown on the opposite and the following pages.

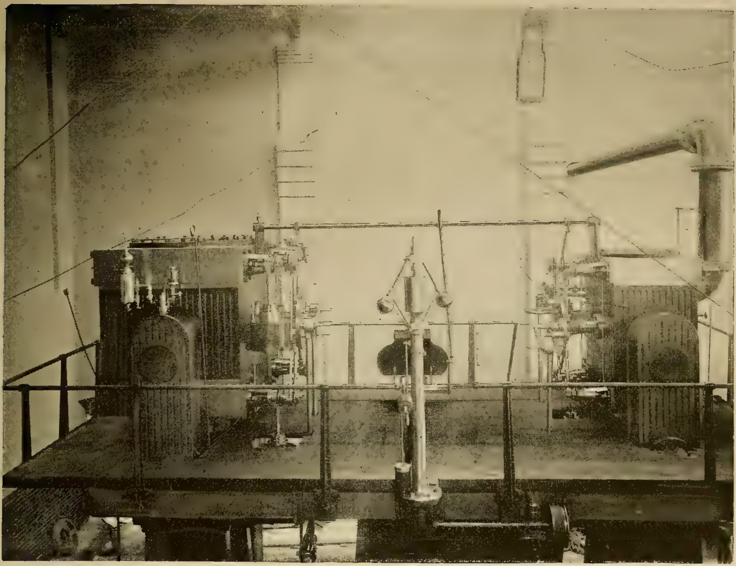
The first of these represents a vertical Corliss cross-compound, condensing engine, built by the Philadelphia Engineering Works, of Philadelphia, Pa. Two engines of this type are now in use in the Hudson Electric Light and Power Company's station at Hoboken, N. J., developing 800 horse-power each, with steam at 125 pounds pressure, and running at a speed of 103 revolutions per minute. The several illustrations which are given of these engines pretty clearly indicate the main features of the design. The high-pressure cylinders are 20 inches in diameter; the low-pressure, 36; and the common stroke also measures 36 inches. The shafts, at the middle, where they carry the fly-wheels, are 14 inches in diameter, and the wheels themselves measure 17½ feet, with 54-inch faces, and weigh about 47,000 pounds each. Their peripheral speed is 5660 feet per minute. Each of the wheels is belted to a countershaft from which, in turn, power is taken to the several electric generators in the station. The engines are fitted up with counterweighted governors of the Porter type, controlling the cut-off in the high-pressure cylinders. Though the speed is somewhat high for release gear engines of this size, the operation has been found to be very satisfactory.

The throttle valve is 7 inches in diameter,—certainly a generous size for a 20-inch cylinder, and the ports and openings through the valves are likewise ample, so that the cards show very little resistance to the steam passing through the cylinders. Between the two cylinders and situated directly below the platform,—indeed forming a part of it,—is a re-heater, rectangular in form, through which extend, from end to end, a series of solid-drawn brass tubes, heated by live steam from the boilers and drained back to them. This heater serves to superheat the steam after having done its work in the high-pressure cylinder, and thereby tends to lessen condensation in the low-pressure cylinder.

An engine of unique design is shown on pages 320 and 321. It was built for spinning mill work, by Messrs. John Musgrave & Sons, of Bolton, England, and is of the quadruple expansion type of which, more recently, there have been several examples for stationary purposes. Curiously enough, while the three-throw crankshaft has been found most suitable for triple-expansion engines, few engineers, if, indeed, any, have thought of using a four-throw crank with quadruple expansion engines. Various forms have been adopted, the two higher pressure cylinders in vertical designs being placed usually above the lower pressure cylinders, with two cranks. Messrs. Musgrave & Sons, however, adopted a unique and distinctive arrangement.



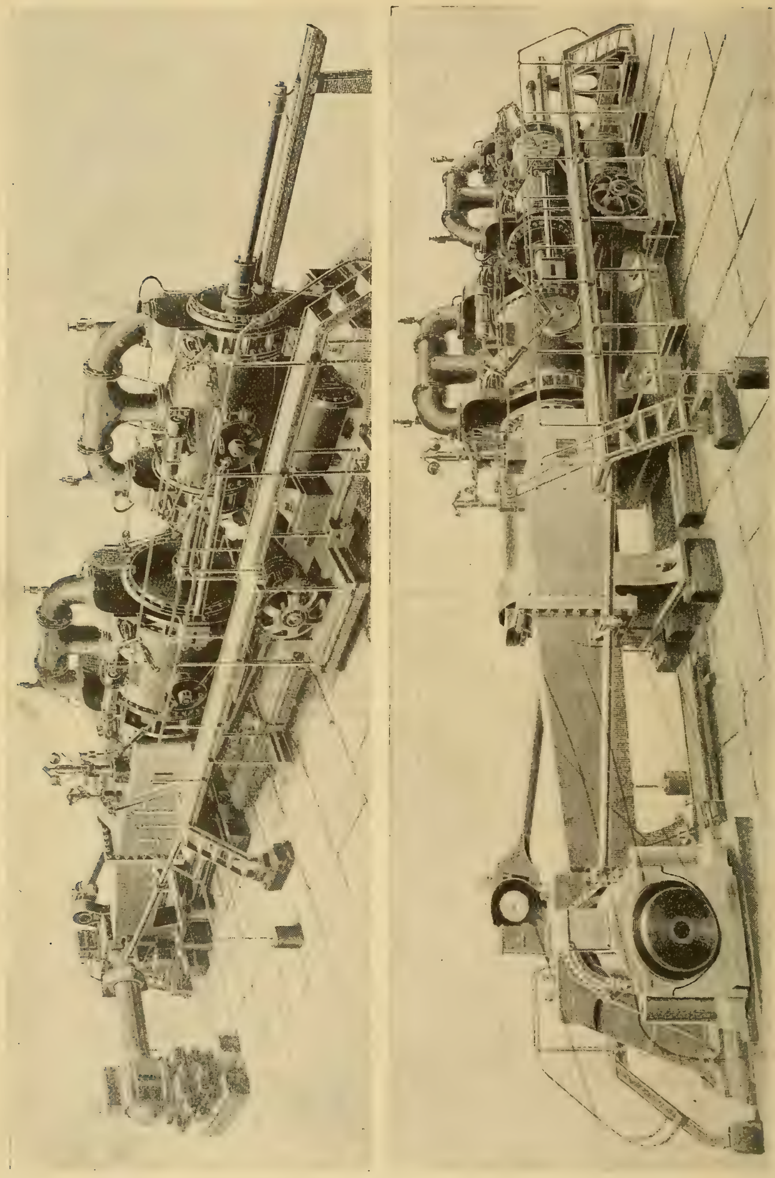
SIDE ELEVATIONS OF VERTICAL CORLISS, COMPOUND ENGINE.



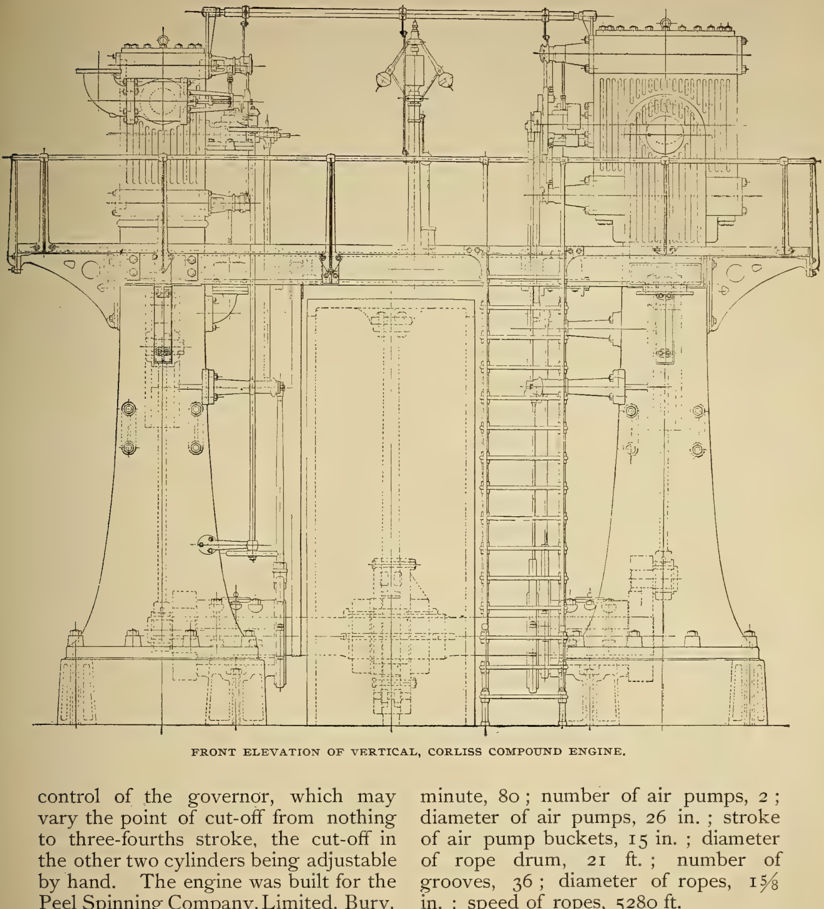
VIEW AT PLATFORM LEVEL OF VERTICAL, CORLISS COMPOUND ENGINE.

According to the particulars given of the engine in Engineering, of London, the cylinders are disposed in pairs on each side of the fly-wheel or rope drum, the two higher pressure cylinders being on one side and the two lower pressure cylinders on the other side. The crossheads of each pair of cylinders are connected by means of a pair of links and a triangular connecting rod to a single crank, as shown in the engraving on page 320. The two cranks of the engine being opposite to each other, the weights of the two sets of reciprocating parts balance each other. Although the crossheads of both cylinders are connected to one crank, they are never at the ends of their respective strokes at the same time, so that there are no dead centres to the engine. The turning effort, indeed, is the same as if the crossheads were connected to cranks set nearly at right angles to each other. In other words, when one piston is at the end of its stroke, the other is nearly in its middle position and has a very effective leverage to turn the crank. Besides, the strains on the crank are gradually changed around the crank pin from one side to the other, and never suddenly reversed, as with an ordinary engine, so that the vibration or jarring is minimized. The triangular connecting rod vibrates on a pin in the ends of a pair of levers swinging on a fixed centre outside of the frame. Extensions of the levers are made use of to work the air pumps. The arc formed by this swinging lever, as well as the circular path of the crank pin, gives the ends of the triangular rod a vibrating motion, so that the ends of the rods move vertically, and thus reduce the pressure on the guides.

The general arrangement of the engine is very compact. The cylinders are all provided with Corliss valves, the admission valves for the high-pressure and first intermediate being under the



1600 HORSE-POWER MILL ENGINE, BUILT BY HICK, HARGREAVES & CO., BOLTON, ENGLAND.



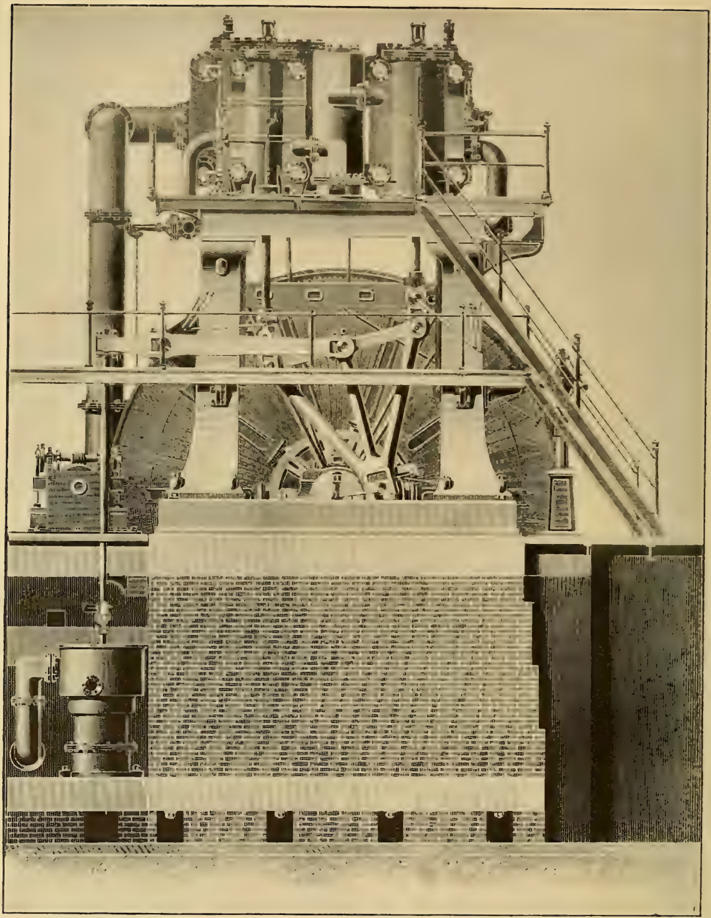
FRONT ELEVATION OF VERTICAL, CORLISS COMPOUND ENGINE.

control of the governor, which may vary the point of cut-off from nothing to three-fourths stroke, the cut-off in the other two cylinders being adjustable by hand. The engine was built for the Peel Spinning Company, Limited, Bury, England, and will develop 1600 horsepower when fully loaded, and when working with 200 pounds steam pressure. The mill will contain 104,000 spindles. The following are the leading dimensions :

Diameter of high-pressure cylinder, 18 in. ; diameter of first intermediate cylinder, 26 in. ; diameter of second intermediate cylinder, 37 in. ; diameter of low-pressure cylinder, 54 in. ; stroke of pistons, 4 ft. 6 in. ; revolutions per minute, 80 ; number of air pumps, 2 ; diameter of air pumps, 26 in. ; stroke of air pump buckets, 15 in. ; diameter of rope drum, 21 ft. ; number of grooves, 36 ; diameter of ropes, 1⅝ in. ; speed of ropes, 5280 ft.

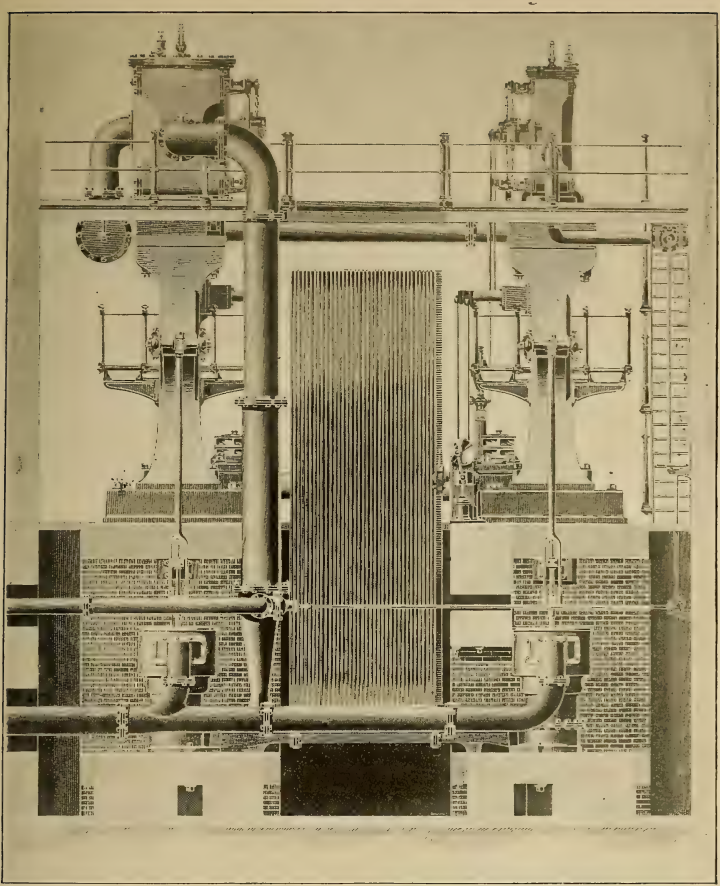
Since building the engine here shown Messrs. Musgrave & Sons have turned out several others of the same design and for similar work.

Another spinning mill engine, also of English make, coming from the works of Messrs. Hick, Hargreaves & Co., Limited, of Bolton, is shown on page 318, the illustrations and particulars also being reproduced by the kind permission of Engineering, of London. The engine was erected in Russia, for



QUADRUPLE EXPANSION ENGINE, BUILT BY JOHN MUSGRAVE & SONS, LTD., BOLTON, ENGLAND.

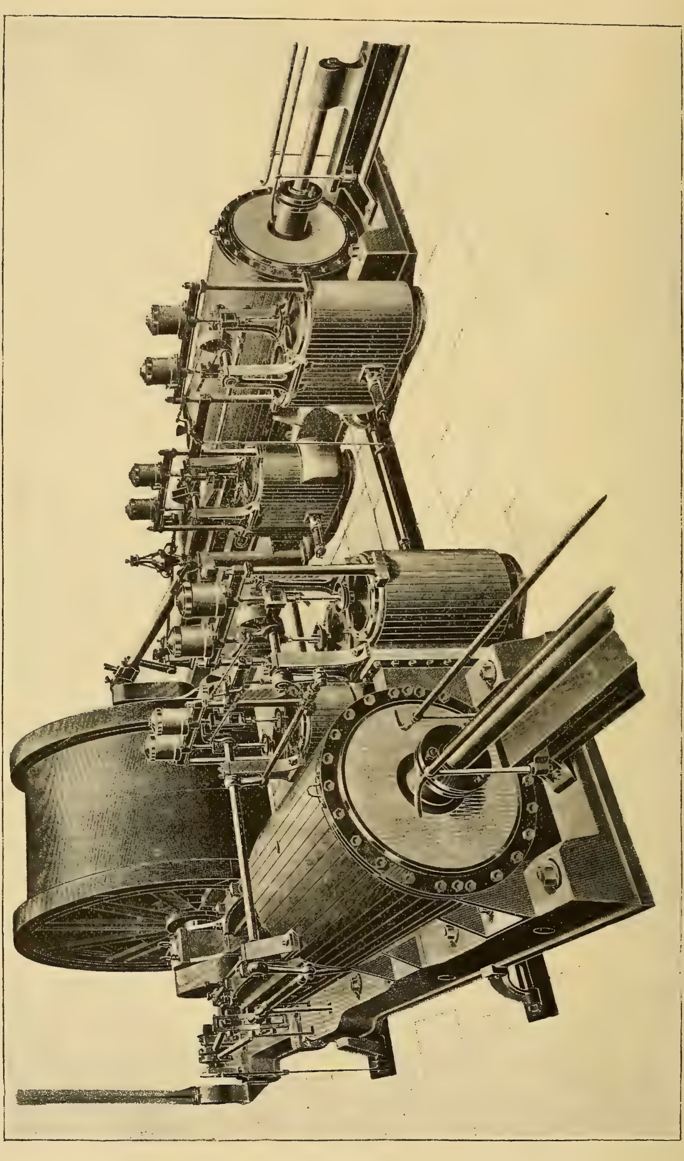
the Nevsky Thread Manufacturing Company, of St. Petersburgh, and its type was largely determined by the necessity that it should occupy an existing foundation originally put down for another engine. As regards the form of frame and class of valve gear, the new engine is of the Corliss type, the main frame being in two pieces, with a bolted joint at the centre of its length, at which point it has a foot supporting it from the foundation, embodied with a stay bracket connecting the upper and lower crosshead guides. The half of the frame nearest the cylinders is a massive casting weighing some 15 tons, fitted with separate and adjustable crosshead guide-bars. The low-press-



QUADRUPLE EXPANSION ENGINE BUILT BY JOHN MUSGRAVE & SONS, LTD., BOLTON, ENGLAND.

ure cylinder is bolted directly to this frame, and both cylinders are carried on a deep girder bedplate, arranged to maintain them in line vertically and laterally, but to leave them free to slide longitudinally, the strains in this last direction being entirely borne by two turned wrought iron stays having T ends bolted to the cylinders.

Each cylinder is built up of a working barrel, a jacket, and two end pieces containing the valve chambers, a method of construction which substitutes four comparatively simple castings, each of which can be cast of the metal most suited to its purpose, for a single casting of a complicated character, which would have to be cast of a soft mixture. This plan has the further advantage of simplifying repairs.



COAL MINE HOISTING ENGINE, BUILT BY THORNEWILL & WARHAM, BURTON-ON-TRENT, ENGLAND.

Each cylinder has its barrel and covers jacketed, and takes its steam supply through its own jacket, special arrangements being made for draining the jackets into large receivers fitted with gauge glasses, traps, and blow-through valves. Apart from the considerable economy claimed to result from this method of jacketing, due to the perfect circulation obtained, it has important practical advantages. No unsightly pipes are required above the floor level, and the barrel and jacket are maintained at one uniform temperature, avoiding the unequal expansion which is found to be a frequent source of trouble with long-stroke jacketed cylinders. Both cylinders are fitted with Corliss valves and gear, driven through bevel gearing from the crankshaft, by an inclined shaft, and a cross-shaft between the cylinders. The steam valves are worked on one side of the engine, and the exhaust on the other, the resulting separation of the eccentrics, of which there are two for steam and two for exhaust, rendering them easily accessible for adjustment. The piston rod is supported between the cylinders by an adjustable brass block, and both it and the valve spindles have metallic packing throughout. The crankshaft is of Siemens–Martin steel, bored throughout its length to ascertain its internal soundness, and the journals are each provided with a pump to return the oil from a lower receiving cistern fitted with strainers, to an upper supply box with glass sides. The fly-wheel is grooved for rope driving and built up of two bosses, with two sets of arms socketed into the bosses and bolted to the rim segments, the joints throughout being accurately machined. The wheel is cased with wood and has a barring rack cast on the inside of the rim, a barring engine being provided for moving or starting the engine.

In cotton spinning, uniformity of speed is of great importance, and the heavy fly-wheel running at a high peripheral velocity is sufficient to prevent any perceptible variation in any one revolution. To maintain the number of revolutions per minute also constant, in spite of changes of load and steam pressure, the engine is fitted with a Knowles supplementary governor, in addition to the powerful high speed main governor, both being driven off the inclined shaft. A safety trip gear is fitted to release the high-pressure trip-rods, and so cut off the steam supply in case of the failure of the gearing driving the main governor, and, as a further precaution, the main steam valve is fitted with an electrical stop motion, arranged to act at overspeed, and worked by push buttons from various parts of the mill. The air-pump is vertical, driven by links and plate levers off the crosshead gudgeons, the cover being fitted with hinged relief valves, and the condenser is provided with a high level supplementary injection for use at starting. The leading dimensions of the engine are :

Cylinders, diameters....	38 in. and 64 in.
Cylinders, stroke.......	6 ft.
Air pump..............	38 in. diameter by 30 in. stroke.
Piston-rod diameters...	5½ in., 7½ in., 9 in.
Connecting-rod, length, centres..............	17 ft. 6 in.
Crank-pin..............	12 in. diameter by 14 in. long.
Crank neck journal.....	20 in. diameter by 31½ in. long.
Out end journal........	20 in. diameter by 36 in. long.
Fly-wheel, diameter....	32 ft.
Fly-wheel, number of ropes...............	30
Fly-wheel, weight	84 tons.
Total length of engine..	69 ft. 4½ in.
Total weight of engine.	213 tons.

At 90 pounds boiler pressure and 50 revolutions per minute the engine is designed to develop 1600 indicated horse-power.

Still another engine, of somewhat different type, being a hoisting engine, built for one of the mines of the Powell-Duffryn Colliery Company by Messrs. Thornewill & Warham, of Burton-on-Trent, England, is shown herewith, the illustration as given on the opposite page being largely left to tell its own story. The engines have cylinder 42 inches in diameter and of 6-foot stroke. The winding drum is 24 feet in diameter, and carries 9 tons 4 hundredweights of rope, two cages and their chains weighing 5 tons 4 hundredweights together, tubs weighing 19 hundredweights, and coal amounting to 2 tons 10 hundredweights per lift. The engines were built according to the specifications of Mr. E. M. Hann, general manager of the Powell–Duffryn Company.

A NEW FORM OF PRONY BRAKE.

By R. C. Carpenter, M. Am. Soc. M. E.

A NEW form of Prony brake, recently described before the American Society of Mechanical Engineers, and illustrated in the engraving on the opposite page was designed by the writer about two years ago, and three such brakes, each of about 60 horse-power capacity, have been in use on the experimental engine of the Sibley College laboratories at Ithaca, N. Y., for a considerable portion of that time.

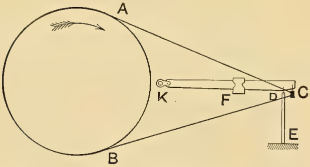


FIG. 1.—SELF-REGULATING BRAKE DEVICE.

The brake consists, in each case, of a tube of copper, with an elliptical section, which nearly encircles the brake wheel. Outside the copper tube is an adjustable band or belt of sheet steel, which prevents the copper tube from expanding. Water pressure is applied to the copper tube by means of hose connections made near the centre of the wheel to water pipes, the amount of pressure being regulated by throttling the admission and discharge valves. As the external diameter of the copper tube cannot change, the internal pressure causes the inner surface to rub against the wheel, producing the friction which is used to absorb the work. To prevent the wearing of the inner surface of the copper tube, a thin sheet of steel or Russia iron is inserted between the tube and the brake wheel, and connected to the brake so as not to revolve.

This brake has proved very satisfactory; the work is readily absorbed by varying the opening of the supply and discharge valves, and no trouble has been experienced on long runs from heat or irregular friction of the brake.

In Fig. 2, which represents an elevation of a wheel, with the brake attached, the principal parts are: *A*, supply pipe; *B*, discharge pipe; *C*, brake; *D*, sheet-iron liner; *F*, external strap of sheet-iron; *G*, adjusting bolts in external strap; *H*, arms of brake riveted to external strap; *J*, support for brake arm, to be carried on the platform of the weighing scale. The wheel itself is 4 feet in diameter, and has a 12-inch face. The small detail view represents a section of the brake and of the rim of the wheel. The elliptical brake is marked *C*, the larger diameter being 12 inches, and the shorter one, ¾ inch; *F*, is the external strap, and *D* is the sheet-iron liner. Another merit, which in some cases may be of little moment, but which was of considerable importance at the time of its erection, was the fact that the first cost was small, the brakes not costing over fifty dollars each.

Professor C. W. Scribner designed a self-regulating device which I consider of great merit, but which, because of pressure of other work, has not yet been applied to the brakes just described. There is, however, no doubt of the effectiveness of the design, and a description of it is, therefore, given. So far as the writer knows, every previous device for automatic regulation of the work absorbed by a brake requires the rotation of the wheel to be such as to tend to move the free end of the brake arm in an upward direction. This is often objectionable, and sometimes an element of danger. In this case Professor Scribner permits a downward motion of the brake arm, and yet succeeds in securing motion sufficient to adjust the tension on the brake.

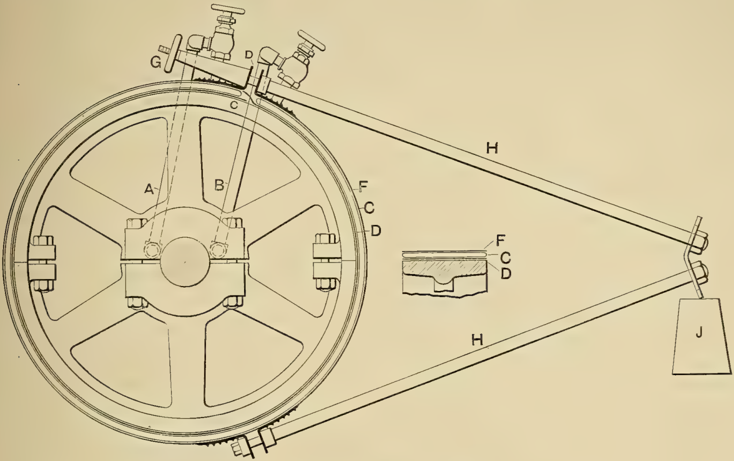
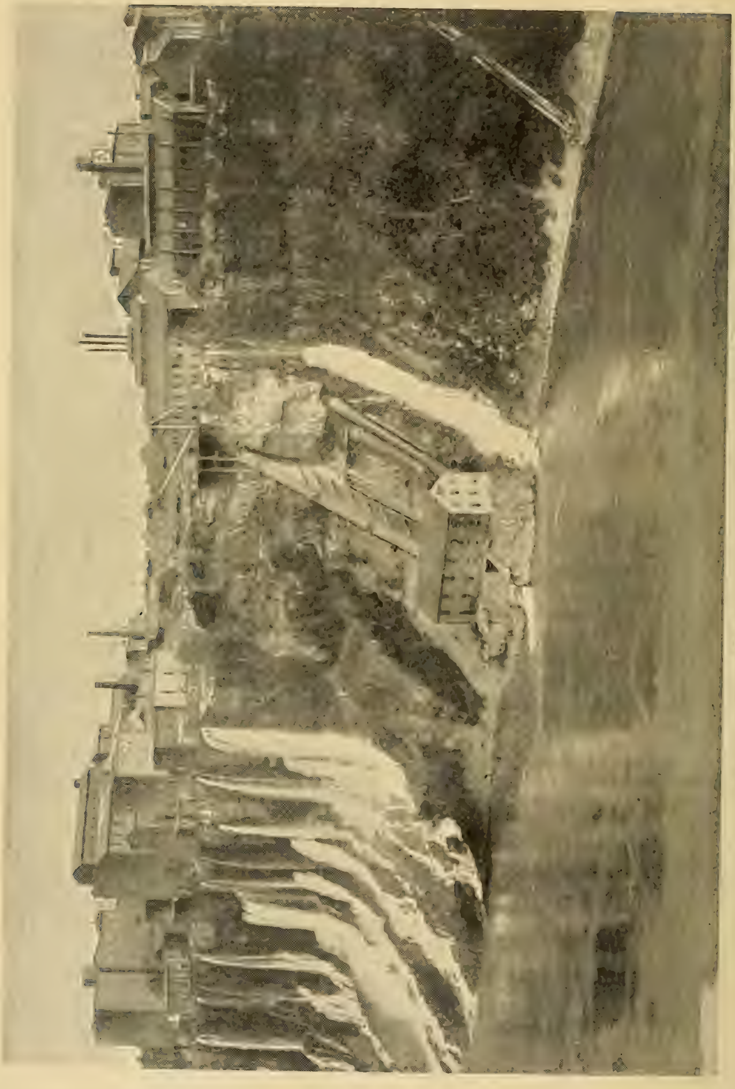


FIG. 2.—BRAKE APPLIED TO WHEEL.

The general method of securing the adjustment is shown in Fig. 1, in which *AC* and *BC* are the brake arms; these rest on the end of a horizontal lever *KC*. This lever is supported at *D* by a knife edge on the fixed support *DE*. A movable weight *F* is placed on the arm of the lever at any point needed to give the required brake load. If the brake load be too great, the pressure at *C* is greater than at *F*, and the point *K* of the lever rises. On the other hand, if the brake load is too small the pressure at *F* is greater than at *C*, and the end *K* of the brake arm falls. The motion of this point can readily be utilized to decrease or increase the tension on the brake as required. In this case this motion will be utilized to regulate the opening of the supply valves and to vary the pressure on the brake. The weight *F* can also be utilized to weigh the load.



THE MILLS OF THE CLIFF PAPER COMPANY AT NIAGARA FALLS, N. Y.

A NEW DEVELOPMENT OF POWER AT NIAGARA.

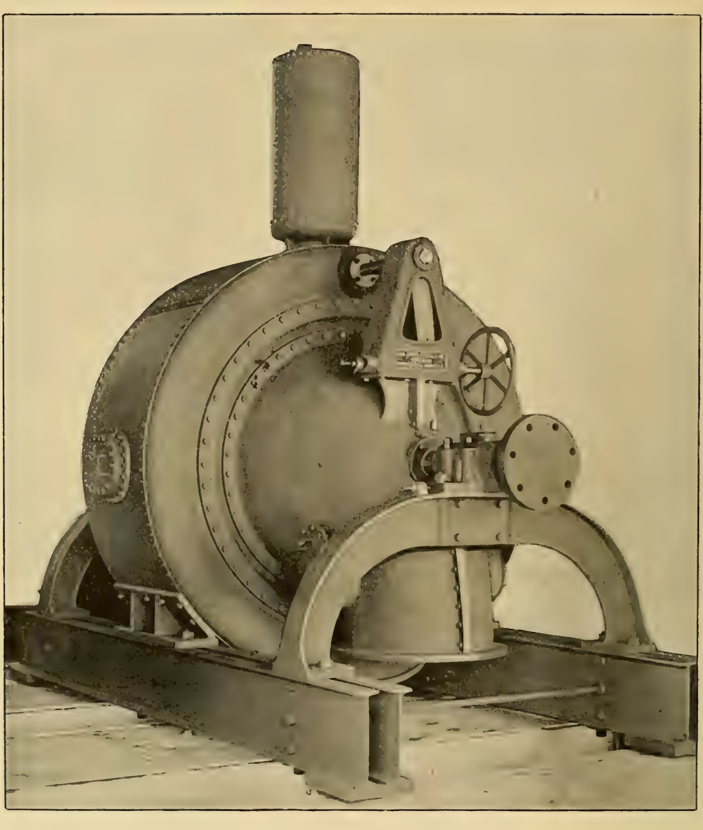
By W. C. Johnson, M. Am. Soc. C. E.

IT was stated in the article in this magazine of June, 1892, on the Niagara Tunnel, that the power available by the old hydraulic canal was all used. It is true that all the water is being drawn from this canal that it is capable of supplying. The contracts made with the original projectors of this canal in 1842, by which the present company hold their land grants, gave them the land only to the edge of the high bank of the Niagara river, with the right of working down the face of the cliff one hundred feet. It was not supposed to be possible that a water-wheel could be built to run under a greater head than one hundred feet. The Niagara Falls Hydraulic Power and Manufacturing Company, the present owners of this hydraulic canal, have obtained the slope between the edge of the high bank and the water of the river, but previous to this, the mills which take the water supplied by the canal had been built, and discharged the water used at depths varying from fifty to one hundred feet below the water in the canal. Thus more than one-half the power which might be obtained from this canal was wasted.

Among the lessees of the Hydraulic Power Company are the Cliff Paper Company, whose mills are shown in the illustration on the opposite page. Their power was supplied by a wheel set in a shaft about two hundred feet back from the edge of the high bank, and discharging the water used through a tunnel from the face of the bank at a depth of about seventy-five feet below the water in the canal and more than one hundred and twenty-five feet above the water in the river below. They were desirous of increasing their facilities by adding a large pulp making plant, and being unable to obtain any additional supply of water for use on the wheel that was driving their mill, the writer devised a plan for obtaining the desired power from the water which had been running to waste.

On the slope back of their mill the loose and disintegrated rock was cleared away, and a space fifty by one hundred feet was leveled for foundations near the edge of the water. It was found that at this elevation we were upon a stratum of solid Medina sandstone, affording excellent foundations for heavy machinery. The foundations were laid high enough to place the first floor of the mill above the highest water in the river, which brings it about sixteen feet above the ordinary water level. In connection with this it may be interesting to note that observations, taken by the writer for the past five years, show an extreme fluctuation in the water of the river below the falls of about thirty feet, due, doubtless, to the contracted channel at the beginning of the rapids about one mile below.

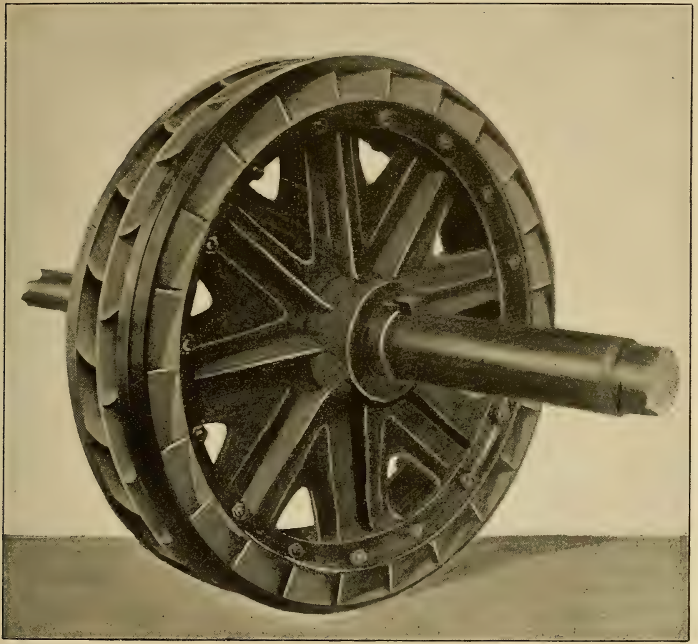
The supply of water for the wheels was obtained by excavating a short tunnel into the face of the bank and connecting at the side of the tunnel through which the water is discharged from the wheels running the mills above. At the mouth of this new tunnel a penstock pipe, eight feet in diameter, was walled in and extended along the face of the bank to the mill below, as seen in the illustration. A dam was thrown across the mouth of the old tunnel, of a sufficient height to turn the water through the side opening into the penstock pipe of the lower mill, and leaving space enough between the top of the dam and the roof of the tunnel to permit the water, discharged from the mill above, to flow out along



ONE OF THE NIAGARA LEFFEL TURBINES COMPLETE.

the old course whenever it was not needed for running the wheels below. This opening into the new penstock was made capable of being closed by a sliding gate which can be worked from the mill above, whenever it is desired to shut the water out of the penstock leading to the lower mill. A pipe was provided, by which water can be discharged into the tail race of the old wheel pit without passing through the wheels that drive the mills above, thus making the two plants entirely independent of each other. The eight-foot penstock pipe, seen in the engraving, connects at the bottom with a trunk, ten feet in diameter, placed lengthwise of the building in the basement. The ten-foot trunk, as well as the lower portion of the eight-foot pen stock, is built of boiler iron, three-eighths of an inch in thickness, and doubled riveted throughout.

The form of wheel used is a double-discharge, horizontal turbine, sixty inches in diameter, designed by Mr. J. F. Sparks, engineer of the James Leffel & Company, of Springfield, Ohio, to meet the requirements of the specifications, which called for a speed of two hundred and twenty-five revolutions under a head of one hundred and twenty-five feet, and using a certain quantity of water for each ton of wood pulp ground. The wheel proper, or runner, is shown on this page and the wheel complete, with case, shaft, bearings and supporting girders is represented on opposite page. The weight of the wheel and case is about thirty tons, and, when in operation, the water filling the case adds some ten tons more to this figure. The wheels are set so that the centres of the shafts are one foot above the first floor of the mill. The ends of the supporting beams are carried on two heavy walls, fourteen and one-half feet apart, running transversely across the mill, and extending out to the edge of the water. The space between these walls forms the tail race, and from it the water is discharged as shown. The outside wall of the mill, on the river side, is carried across this opening on an arch. Underneath the mill, and to a point about fifteen feet outside, the tail race is excavated about six feet below the ordinary surface of the water in the river.



THE WHEEL PROPER.

About fifteen feet outside the mill, a wall is thrown across the opening, forming a dam, the top of which is at the ordinary river level, for the purpose of holding the water back and assuring a seal for the draft-tubes in case of low water in the river. In the centre of the mill, the ten-foot trunk extends across this opening, and is supported by the walls forming its sides. In the centre of the opening, supply pipes, five feet in diameter, lead from each side of the trunk to the bottom of the cases of the two wheels set on each side of the mill, passing up between the draft-tubes which lead out of each side of the wheel cases, and coming down a little below the top of the dam at the mouth of the tail race.

No attempt has been made to measure the amount of power actually developed by the two wheels, but it is probably from eleven to twelve hundred horse-power each. Along each side of the lower floor of the mill extend the line shafts, the water-wheels being in the centre and two pulp grinders on either side, making eight grinders in all. The couplings on each side of the water-wheels are fitted with plates between the faces which can be readily slipped out, thus detaching two grinders and leaving each wheel free to drive the other two so that an accident to any one grinder cannot stop more than one-fourth of the plant.

The ground wood from both lines of grinders flows to a tank in the basement from which it is pumped to another tank in the roof; from this it flows to the screens and thence to the wet machines. Instead of the finished product being cut off and bundled, it is scraped from the roll by a knife, and drops on a conveyor running lengthwise of the building. By this it is deposited on a chain conveyor and carried up an incline to the mills above. The returning side of the same conveyor takes the wood, which has been sawed and barked in the mill above, down to the grinders. The only hand labor required in the pulp mill is the placing of the wood in the grinders. Running in the same incline with the conveyor is a platform car for transporting men and materials between the mill on top of the bank and the one below.

The mill has been running for a little over six months with hardly an hour's stoppage for repairs of any kind and has a capacity of about thirty-two tons of wood pulp per day. The success of this plant has demonstrated, first, that the hitherto unused slope between the high bank and the water of the river below the falls, is an ideal place for the development of power. When the materials used and the manufactured product are of such a character as to admit of being readily conveyed up and down, and when the process of manufacture is such as to require little space as compared with the amount of power used, no better location can be found for a manufacturing plant. The location is admirably suited for the generation of electricity or the compression of air for transmitting power to other points. In this way will be utilized not only the several thousand horsepowers now running to waste from the tail races of the mills already in operation on the hydraulic canal, but much of the large increase soon to be made available by the enlargment of this canal now in progress.

THE RETURN CIRCUIT OF ELECTRIC RAILROADS.

By Thos. J. McTighe.

THE progress of the trolley system of electric railways has been so rapid as to become almost bewildering. A multitude of improvements has been added, the necessary result of careful thought and ingenuity of the electrical engineer, and the critical study of the practical railway manager and his assistants. But this has been mostly true of the track and overhead construction and the cars and power equipment. The return circuit, as pointed out by the author in a paper recently read before the Street Railway Association of the State of New York, has been rather neglected, being largely a case "out of sight, out of mind." Originally installed on a basis evidencing immature study, and necessarily without experience, it has been left to shift for itself, or rely upon Mother Earth to open a frictionless path for the nearly exhausted pressure to get back to the power house. Few practical investigations of efficiency have been made, and data are meagre. Yet the return circuit is in some respects as important a factor of the system as the overhead circuit, and a moment's thought will show this to be true. The efficiency of an electric circuit depends upon the resistance of all the parts. We carefully figure out the amount and size of overhead wire so as to bring down the waste of energy in transmitting current to the motors, and we should be logically bound just as carefully to plan out the return circuit. Track rails are necessary, and they are getting better and bigger for our circuit purposes, and I believe that it will not be long before the absurd and costly supplementary wire will have joined the vast army of discarded expedients, and with it the earth as a permanent part of the return circuit, except in some special cases.

On a wet day in moderate weather the earth is available, and to a very large extent, I believe, considering that with a seventy-pound girder rail and double track we have something like 30,000 square feet of earth contact per mile of track. But we cannot rely upon this doing us the same service in long spells of dry weather. Still more, we cannot rely upon it doing any good whatever in severe winter weather. It is not uncommon in this state for frost to penetrate three feet in the ground and to stay there for a whole winter. Under such circumstances the earth return must go out of our calculation. It is during severe winter that we want to realize our very last watt in the hard pulls we must contend with almost daily.

We are told in mechanics that the strength of a structure is measured by that of its weakest part under the most unfavorable conditions it is to meet. Similarly, in a compound electric circuit the total resistance must depend upon the condition of highest resistance to be met with in any of its component parts. We must plan so as to have our return circuit efficient in the most prolonged summer drought, and in the most severe frosts of winter. Ground plates and pipes laid below permanent water level are a refuge in a few favored localities, but the same can hardly be said of plates and pipes laid in the ground whose moisture depends upon the wayward elements.

I have made a large number of calculations as to what should be the total resistance per mile of the return circuit under different methods of the construction of the circuit. In making these calculations I have eliminated the conductivity of the earth, because in average winter weather the earth turns a very cold shoulder to the track. I have eliminated the conductivity of the fishplates, because I believe that under average conditions the comparatively small areas of contact surface are too much oxidized to be of much benefit. The most approved form of fishplate bears only at its upper and lower edges against the rail. The rail and plates are merely special forms of structural steel, rolled while hot, heavily oxidized at best, and usually rusted still more before being applied. Two such rolled surfaces never come into good contact throughout, and it cannot be expected. A straight edge laid along the bearing surface of the ordinary fishplate will convince any one who takes the trouble. Even on our magnificently constructed and continuously maintained steam trunk lines I have, on examination with my knife blade, rarely found a fit so perfect that I could not enter the blade at one or more points.

I have eliminated all the refinements upon which exact scientific analysis of the subject would insist, such as changes of temperature, moisture and other conditions which are more or less insignificant in the practical work. I have based the figures on the ratio of six to one in comparing the resistance of the ordinary soft steel rails with that of our usual commercial copper, and for the latter I have followed the ordinary tables adopted by the wire manufacturers.

I have not discriminated between the different assignable values for resistance in the various forms of rail bonds, and have calculated only for the specific metal used in the comparisons, leaving the merits and demerits of the form out of the question. I will refer to the last later on. In studying the general situation prior to constructing, in the spring of 1891, the railway system of Lincoln, Neb. (of which my firm were supervising engineers), I investigated the subject somewhat closely. Though, at the time and under the local conditions, an advocate of iron rail bonds, I was and am yet convinced that supplementary ground wires are an unwise extravagance. I will try to give you the reasons for this belief.

In steel rails we usually say that every ten pounds weight per yard means one square inch of cross sectional area. And every square inch of such area can be brought to terms of copper by dividing by six. The resistance is easily determined, and we thus readily arrive at some important results for comparison. For example, take the average city railway rail as being a seventy-pound girder. Its area is substantially seven square inches, and the four rails of a double track make twenty-eight square inches, equal to a single steel bar four inches thick by seven inches wide. This is electrically equal to a bar of copper having 4.66 square inches in area or, in other words, a copper conductor one inch thick and almost five inches wide. With such a magnificent path for our returning current, does it not seem absurd to supplement it with a No. 0 wire, whose area is that of a rod a little over a quarter of an inch square? But when we find the rail resistance per mile to be but .0086 ohm, while that of the No. 0 wire is just sixty times greater, the absurdity seems to grow, and it becomes a case of sending a very small boy to do a very big man's work, with the man standing idle on the spot. Calculating in like manner for some usual weights of rails, I obtain the figures given in Table I.

As it would be tedious to carry all these into further comparisons, I will carry the analysis out, mainly on the seventy-pound rail, with one reference to the big ninety-pound rail now being extensively used in large cities.

Cases 1, 2 and 11 in Table II are given as representing the system on which probably a large majority of electric railways have been constructed. A few roads have the supplementary doubled along both tracks, and a few have used slightly larger connected wires than No. 4 B. & S. But I am trying to give the average of what has been accepted as first-class work, and will try to show it can be vastly improved. The West End and the Brooklyn City Railroad companies laid their tracks with double supplementary copper wires (No. 0 B. & S.), but found them totaly inadequate, and now have put up many miles of huge return feeders or mains at great cost. Even these are inadequate.

TABLE I.—Double Track.

Size of Rails.	Total Sectional Area.	Equivalent in Copper.			Resistance per mile.
		Area.	Thick.	Wide.	
50	20 sq. in.	3.33 sq. in.	1 in.	3.33 in.	0.0121 Ohm.
60 "	24 "	4.00 "	1 "	4.00 "	0.0101 "
70 "	28 "	4.66 "	1 "	4.66 "	0.0086 "
80 "	32 "	5.33 "	1 "	5.33 "	0.0075 "
90 "	36 "	6.00 "	1 "	6.00 "	0.0067 "

TABLE II.—Seventy Pound Rail, Double Track.

Case.	Description.
1	No. 4 cop. bonds, connectors and two No. 0 cop. supplementaries.
2	No. 4 cop. connectors to rail ends, two No. 0 cop. supplementaries.
3	36 inch No. 0 iron bonds, single. No supplementary.
4	36 " " 0 " " double. " "
5	36 " " 0 copper bonds, single. No supplementary.
6	12 " " 0 " " " " "
7	36 " " 00 " " " " "
8	12 " " 00 " " " " "
9	36 " " 000 " " " " "
10	12 " " 000 " " " " "
	90 LB. RAIL, DOUBLE TRACK.
11	No. 4 cop. connectors to rail ends, four No. 0 supplementaries.
12	12 inch No. 0000 copper bonds, double. No supplementary.

In Brooklyn these return mains (500,000 circular mils) are, when possible, suspended on the elevated railroad structure. I am informed that occasionally the insulation scrapes off and the return main makes contact with the iron work. Heat enough is developed at this leak to soften the insulation for many feet, thus showing that the resistance of the main return is still too high.

Taking the cases presented in Table II, I have constructed another table, and for the sake of fair comparison I have made the calculations on the same basis of elimination as previously noted. I am not aware that the subject has heretofore been followed up to this extent, and I think Table III will, therefore, be found interesting and perhaps important.

Of course, in localities favored all the year round with wet ground, this table would be seriously astray; but, as I have said, the table is based upon the most unfavorable condition, namely, earth frozen hard for two or three feet deep, and earth conductivity practically *nil.*

I must not take up time with any extensive analysis of Table III, but I cannot forbear pointing out a few striking features. Take cases numbers two and six. The former is, no doubt, used by many of the existing street railroads. Number six is the system of track circuit of the Atlantic avenue railroad, in Brooklyn, N. Y. Number two has a total track resistance of .0586 ohm, and costs for material, about $700 per mile, while number six has a total track resistance of but .0130 ohm, and costs for material, only $144 per mile. In other words, number six, in point of efficiency, is four and a half times a better electric circuit than number two, while costing just about one-fifth as much. In roads likely to have extreme heavy traffic, case number eleven has been adopted, there being four Number 0 supplementary copper wires and the ordinary copper rail bonds or connectors, being thus merely an enlargement of number two, and used in connection with ninety pound rails. In case number twelve, the ninety pound rails are also used, but there are no supplementary wires, and each joint of the rails is supplied with two rail bonds of number 0000 copper wire, each only twelve inches long. Comparing results, it is evident that case number twelve is, electrically, about four times a better circuit than number eleven, while costing only about one-third as much.

Now let us compare case number twelve as it stands, with case number eleven, but adding to the latter two 500,000 circular mils overhead returns connected heavily to the track circuit at frequent intervals. In case number eleven the total track circuit resistance is .0306 ohm; that of the two 500,000 circular mil feeders about .0545 ohm; and the combination circuit measures about .0196 ohm. The cost of the two feeders (insulated) per mile of double track roads would be approximately $2800, to which we add the $1250, cost of track circuit in case eleven, making $4050. In short, though our case number twelve gives us almost three times as efficient an electric circuit as the new case number eleven, the latter costs almost ten times more than number twelve. And yet the West End and Brooklyn City Railroad Companies pin their faith in a circuit like case number eleven.

TABLE III.—Characteristics per mile, double track.

Case Number.	Total R of Rails.	Total R of Rail Bonds.	Total R of Track Circuit.	Fall of Potential for 200 Amp.	Total Energy Expended thus in Track Circuit.	Cost of such per Year at $100 per Kilowatt.	Approx. Cost of Track Circuit Material.
	Ohms.	*Ohms.*	*Ohms.*	*Volts.*	*Watts.*	*Dols.*	*Dols.*
1	.0086	.0335	.0362	7.24	1,448	144.80	700.00
2	.0086	.0671	.0586	11.72	2,344	234.40	700.00
3	.0086	.0796	.0882	17.64	3,528	352.80	90.00
4	.0086	.0398	.0484	9.68	1,936	193.60	180.00
5	.0086	.0133	.0218	4.36	872	87.20	180.00
6	.0086	.0044	.0130	2.60	520	52.00	115.00
7	.0086	.0105	.0191	3.82	764	76.40	200.00
8	.0086	.0035	.0121	2.42	484	48.40	130.00
9	.0086	.0083	.0169	3.38	676	67.60	220.00
10	.0086	.0027	.0113	2.26	452	45.20	150.00
11	.0067	.0335	.0306	6.12	1,224	122.40	1,250.00
12	.0067	.0011	.0078	1.56	312	31.20	432.00

A glance at the sixth and seventh columns of Table III is rather instructive. If we take a medium city system operating twenty miles of double track, the company which uses case number two will pay several thousand dollars per year for the energy wasted in the return circuit, while the company using number six or number eight or number ten, will pay but a trifle in comparison, and save nickels by the quart. I am of the opinion that it would, to-day, well repay any company using copper supplementary wire to rebond its tracks on a basis of perennial low resistance, because on the average it would save the cost of such change in one year, and I say the same to those using iron rail bonds.

There is still another phase to this whole question of the return circuit to which I will briefly refer. I mean the electrolytic decomposition of the rails, when earth is relied upon as the major part of the return circuit. That there is such decomposition must be true. The soil under our paving has for many years been plentifully soaked with ammonia from animal refuse, with ordinary salt in the winters of bygone horse car days, and to these have been added the leakage from the underground gas pipes. Certainly such soil, when wet and in contact with the rails, presents all the requisite features of an active depositing bath, there being no dearth of cathodes below. Hence, so long as a considerable flow of current takes place from rails to earth, there must necessarily be a good deal of direct electrolytic decomposition of the rails. Let me take an extreme case. It would scarcely be an exaggeration to assume that on Tremont street, Boston, or Fulton street, Brooklyn, there is a massing of slowly moving cars, amounting to, say, 100 for one mile of double track. Let the rails used be seventy pound girder, and for the current I should say twenty amperes per car for fifteen hours per day would be a fair average. 100×20×15×365=10,950,000 ampere hours per year. If all this went back to the generator by way of the earth the decomposition of the rails every year would be 7,665,000 grammes, or about 17,000 pounds of iron—nearly eight tons lost from the mile of double track in one year. As the mile of seventy-pound rails would only aggregate 220 tons, it would not be many years, at that rate, till the rails would be qualified for a pension for loss of both feet incurred in the service, and in some time we might have an illustration of the proverbial "two streaks of rust and a right of way."

I have assumed an extreme case, but I have no doubt that there is a considerable amount of direct electrolysia of the rails. Nothing can be done to entirely avoid it, but it can be reduced to a minimum by overhauling the track circuit and giving it as great an electrical value as possible, and it might be retarded by dipping the rails before laying, similar to gas and water mains. In abandoning as much as possible the rather uncertain supposed advantages of the earth return, we would to a corresponding degree rid ourselves of troubles with gas and water pipes and telephone circuits, and yet would be as safe from lightning as we are at present.

If it be admitted, then, that it is desirable to obtain from the track structure as great a conducting power as possible, the question arises, how shall it be done? This at once brings us to the subject of rail bonds, and a criticism of the various types used, with a view of arriving at the best from all points of view.

There have not been many types brought out by the manufacturers. Probably the earliest was made of a piece of wire having its ends coiled around two rivets and dipped in solder. This form is still much used, but it is objectionable. By its use four contacts exist at every rail joint, *i. e.* rail to rivet, rivet to wire, wire to rivet and rivet to rail. To insure its position in the rail the rivet must be upset, and this, in a great number of cases, either starts or completely loosens the contact between the rivet and wire. If it escapes this, the constant vibration of the rail sooner or later causes loosening of the wire on the rivet. Once looseness occurs, the bond is of little use. Again, the essential nature of such a rail bond precludes the use of any large wire in its construction. Still, many roads have used them and are still doing so. The wire generally used is No. 4 B. & S., sometimes iron and sometimes copper.

Another type, which has met with much favor, consists of two soft iron pins with enlarged heads, which are drilled transversely to receive the connecting wire which is upset after passing through the heads. This form is open to the same objections as the previous ones, being in three pieces, the integrity of whose contact is almost sure sooner or later to be destroyed, whether the intermediate wire is iron or copper.

Later on appeared the ingenious and, from a purely constructive aspect, very economical, "channel pin." It met an enormous sale, and it is to-day in extensive use. It requires three pieces, is not capable of riveting in the rail, and its form prevents the pin and wire from completely filling the hole in the rail, and rapid corrosion of contact is inevitable. Being merely driven wedge-like into the rail hole its stay is not reliable, and by corrosion and continual vibration it becomes loose and almost valueless. There is, too, a tendency for the workman to force the wire against the sharp edge of the hole while driving the pin, thus weakening the wire very materially. It too, like the rivet and wire bond, has a limitation as to the size of the connecting wire. No matter how carefully the mechanics of the job are attended to, we have a mere plug driven in a hole, and so between the rail and channel pin and the car wheels is a very good illustration of a cask, a bung and a bung starter, with the odds against the bung.

Another type of rail bond is that composed of a piece of copper wire with cast copper rivets electrically welded thereto on projecting stems the size of the wire. This is an attempt in the right direction, but does not work out in practice. The electric weld is apparently uncertain, the union in many cases under my inspection being so imperfect that it could be broken by hand. The small copper castings exhibit radial crystallization, making welding difficult. Many also break in applying to the rails, and such happenings destroy confidence.

I now come to what is known as the "solid one-piece bond," which has sprung into great favor. This solid, one-piece rail bond is simplicity itself. It is merely a wire with expansion curves at its ends, on each of which a heavy shoulder is swaged from the wire itself, so that both the rivet ends thus formed and the intermediate wire are all one solid integral piece. From rivet to rivet there can be no failure of contact, except by forcible rupture or total corrosion, and there can be no failure of contact between bond and rail, because when the rivet end is properly headed up, the connection made is perfectly water-tight and air-tight, and is proof against pounding and vibration. There is no solder required, no parts to shake loose, and there is no restriction in size of wire, as the bond can be made of No. 4 wire, and it can be made of No. 0000, and larger if desired.

I suppose the great majority of rail bonds used span around the fishplates, which nowadays are quite long. My belief is that this is a mistake. Table III will show what a difference there is in resistance in the track circuit as between thirty-six inch and twelve inch bonds. The twelve inch bond has the advantage in the total track resistance of from forty per cent. to fifty per cent. A twelve-inch solid bond, with its expansion curves, makes a distance between rivet centres of about eight inches. Electrically considered, it does not matter what part of the rail end is used for bending. The holes can be drilled through the flat tram or through the floor of the rail, four inches from the end, just as readily as through the web or stem. There is no difficulty whatever, and I can imagine no type of track construction forbidding the use of short bonds. I have bonded many miles of track in this manner, and used the twelve-inch bonds and had no trouble. In girder rails I prefer to drill the holes through the flat tram, taper ream the holes from above, and deeply countersink ; then pass the rail bond up from beneath, and head up the ends till the taper and countersink are completely filled. This method has one great advantage, in allowing every rail bond to be inspected at any time without disturbing the paving. The tracks of the Atlantic avenue railroad, in Brooklyn, were bonded in this way with No. 000 copper bonds, eight inches long between rivet centres, and they have given entire satisfaction.

Rail bonds should, after being applied, be either heavily coated with shellac and asphaltum, or have a grooved strip of wood filled with asphaltum slipped around while the compound is soft. This will prevent corrosion.

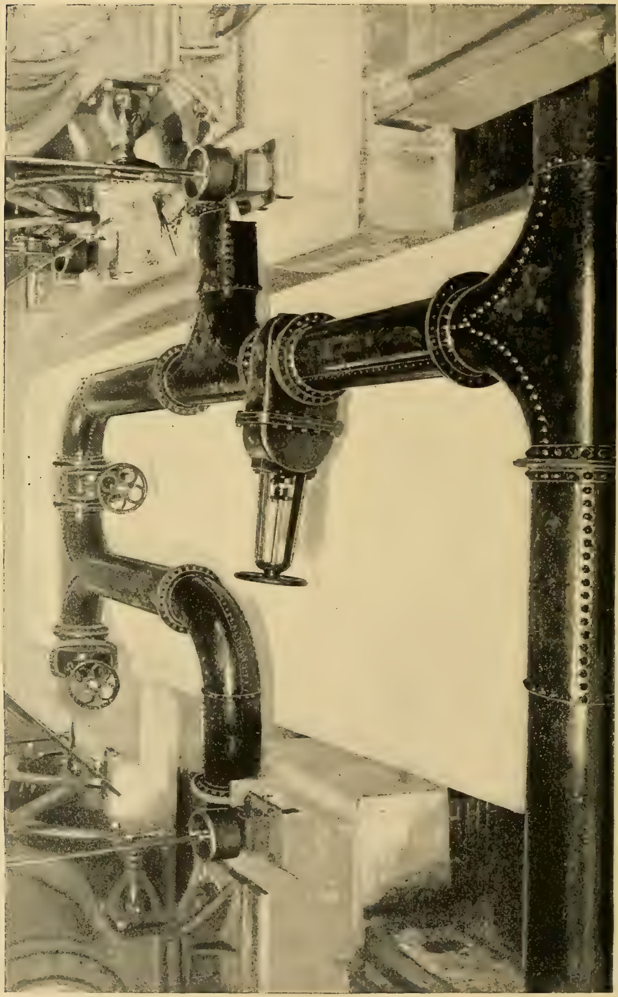
Another important element of the return circuit, in such roads as do not pass the power house, is the main return. Whether earth circuit is used or not, there should be a heavy connection from the generator or switchboard by the shortest route to the rails. Such a course is generally adopted, but the size of the conductor is apt to be too small. I have seen several cases of serious inadequacy in this direction, so much, indeed, as to heat the main return. I had occasion once to discuss the question with a gentleman who called himself an electrical engineer, and who had engineered several railways of considerable size. The problem was to return a possible maximum of 5000 ampères about half a mile from tracks to generator. I gave my views, which embodied rather heavy work, and also my calculations for loss of energy, etc. "Nonsense," said he, "four No. 0000 wires would be abundance, because you can lay them in the ground, and the heat will be carried off before harm can be done." It was no use arguing against that; and I utterly failed to persuade him that his four wires would require 320 volts to drive the 5000 ampères through them, *i. e.*, a loss of over 2100 electrical horse-power. Fortunately, that engineer has generally had some check on him, and thus the construction of several monstrosities has been avoided.

The old rails can be advantageously used for the main return in many cases. When it comes to using a large number of heavy copper wires overhead or underground on the one hand, and on the other hand an equivalent capacity of old rails laid underground, the latter is much cheaper, and can be made entirely durable. The rails can be connected by heavy copper plates by riveting, the number of rivets being equal in carrying capacity to that of the rail and plate. The whole structure can be laid in a wooden trough filled with pitch and will remain intact for an indefinite period. A one-rail line of this kind, composed of old sixty-pound flat or centre bearing rail, is as good as a copper bar one inch square, or six No. 0000 copper wires.

I am, therefore, led to the conclusion that the best return circuit is that which complies with the following requirements:

1. Intrinsic resistance low enough to need no help from earth.
2. Utilization, to the utmost practical extent, of the rails as the return conductor.
3. Rail bonds of the heaviest practicable size.
4. Rail bonds of the shortest possible length, consistent with due allowance for expansion and vibration.
5. Rail bonds made of a single piece of wire with integral rivets.
6. Rail bonds tightly riveted to the rails through holes freshly reamed immediately before bonding.
7. Rail bonds so placed as to permit convenient inspection.
8. Rail bonds protected against corrosion.
9. A very liberal use of heavy cross bonds from rail to rail direct, and, in double track, extra heavy cross bonds connecting the two inside rails.
10. An underground main or trunk return from power house to track, and there connected to each line of rails, and low enough in resistance to carry the maximum current with but a nominal drop in potential.

Not one of these requirements is an extravagance, but, on the contrary, their proper application to almost any electric railway in the country would be of immediate and lasting benefit. In new constructions they would be a positive economy in first cost. There is not one of them which cannot be adopted in practice, and it seems obvious that their complete embodiment in any existing road would be immediately noticeable in the power house, and eventually in the dividend.



BUILT-UP EXHAUST PIPING FOR A PAIR OF 2000 H. P. CORLISS ENGINES.

A METHOD OF MAKING LARGE STEAM PIPES.

By Chas. H. Manning, M. Am. Soc. M. E.

THE rapid increase in size of steam plants and of the pressure of steam used in recent years has of necessity changed the design and material of steam pipe. For stationary engines with pressure of from 60 to 80 lbs. per square inch, cast-iron was the generally accepted pipe, whilst for marine purposes copper still holds its place, though the method of manufacturing has changed with the great increase of pressures; but, at best, the copper pipe in large sizes is dangerous, and has cost many lives in the last few years.

Eleven years ago it became necessary for the author to construct several thousand feet of 20-inch steam pipe, besides considerable lengths of 15 and 12-inch sizes, and the satisfactory results obtained led him to describe the methods of construction in a paper recently presented to the American Society of Mechanical Engineers. It was decided to make a mild steel, riveted pipe, with die-forged flanges of the same material, and rivet and calk the flanges. For riveting the pipe an Allen pneumatic riveter was used; and as the extreme reach of the arms of the machine used was about 70 inches, the courses were made of that length, netting, between roundabout seams, 68 inches. I had observed that the greatest difficulty with riveted pipe was keeping the roundabout seams tight, and this was evidently caused by water accumulating about these seams on the bottom of the pipe when steam died out; then, when steam was readmitted to the pipe, these small accumulations of water caused unequal expansion, as the portions covered by them heated much slower than the unprotected surfaces, and in this way leaks were started in the roundabout seams of the bottom. To avoid this, each course was made the frustum of a cone, thus bringing the laps all in one direction, and by placing the large end of the cone up-hill and giving the pipe sufficient grade, it was easy to keep it free of water at all times. This has been entirely successful.

To insure rigidity and tightness, ¼-inch thickness, with double-riveted longitudinal seams and single-riveted roundabouts, was settled on, which of course gives a very large margin of strength; but if building for 160 lbs. pressure or above, I should double rivet the roundabouts also. The plates are received from the mill sheared to the required taper. They are then scarfed at corners, punched to template, planed on outside edges for calking, and then are rolled to circle on rolls having the outer end housing hinged so that it can be let down and the pipe slipped off the roll. For convenience in handling, the lengths are limited to nine courses, making the total length about 51 feet 2 inches, and in these lengths it has been shipped as far as Nashville, Tenn., without mishap. The flanges, except where coming on to valves or other castings, are of ⅜-inch stock, and, for above exceptions, ½-inch stock. They are formed on a cast-iron die with an iron plug driven through with a drop-hammer, and are then trimmed on both edges in the lathe. To avoid making flanges of two different-sized holes to fit the two ends of the pipe, the last course of the pipe at the down-grade end is a parallel course—that is, it is not coned, and is of the size of the large end of the cone. The longitudinal seams are placed quartering 45° from top of pipe, with the laps pointing up so as to be readily accessible for calking. When in place, the flanges are riveted together, and it is preferable to have all valves made with long necks and rivet them in place, so as to avoid all packed joints. Before leaving the shop, headers are bolted to each piece, and it is then calked under a steam pressure of 100 lbs.

The quarter turns for 20-inch pipe are made with a 3-foot radius, and are formed from two sheets on a cast-iron former, and have, when complete, one row of rivets along the back and the other along the throat. Owing to their rigid form, single riveting is found to secure tightness, but to allow for drawing of metal in forming, $\frac{5}{16}$-inch stock is used instead of $\frac{1}{4}$-inch. The tees are made of three sheets, which brings all the riveting on the sides, and are made over formers similarly to the quarter turns. In the flat spandrels sufficient socket stay bolts are used to insure strength. For branches up to 6 inches diameter a threaded composition saddle is riveted to the pipe, but for larger sizes a short piece of pipe of the desired size is made by welding up from sheet metal, and then this is flanged in a cast-iron former to fit the pipe, and riveted on. At the other end a thread may be chased for a cast flange to be screwed on, or a wrought flange may be riveted on, which latter I prefer.

This pipe may be hung in chains, but where practicable I prefer to support it from underneath. With the 20-inch size it should be supported about every 17 feet, and it is my practice to support the 51-foot lengths in three places; at the middle by having a sliding foot consisting of a foot clamped firmly to the pipe and sliding in ways secured on the foundation, and toward the ends by rockers secured to the pipe and rocking on a cast-iron plate. Where expansion is to be provided for, I use a carefully constructed slip-joint, the female portion being provided with legs which slide in guides similar to those of the sliding support of the pipe. These slip-joints are packed with braided asbestos packing, and I find no trouble in keeping them perfectly tight with about one new turn of packing per annum. All large pipes are liable to water-hammer, and a hammer that would completely wreck a cast-iron pipe or split a lap welded pipe from end to end will have little or no effect on the riveted pipe, except to strain the joints of the longitudinal seams; but I have never known a riveted pipe to give out.

This method of making the laps all in one direction is not new, though I supposed it to be so for several years after I began to use it. My belief was changed by coming across a piece of similarly constructed 12-inch pipe in a scrap heap, the piece having the appearance of being twenty or thirty years old, but, of course, the courses were much shorter than I use. Some makers of large riveted pipe use very unsightly cast-iron flanges, which they seldom succeed in keeping tight for any length of time, and the cost is fully as much as with the wrought flanges. The illustration on page 338 shows the exhaust piping of a pair of 2000 H. P. Corliss engines, piped to use one or both cylinders condensing or against back pressure, as desired.

HIGH-TENSION, DIRECT-CURRENT DYNAMOS.

By Francis B. Crocker, E. M.

EXPERIMENTS conducted with two direct-current dynamos of very high potential, formed the topic of a short paper, presented by the author at the Electrical Congress, held at Chicago during the past year. In view of the interest attached to this subject at the present time, recurrence to it here may not be amiss. By very high potential the author means from 5000 to 11,000 volts. Machines of this character have received comparatively little attention either from scientific experimenters or practical engineers.

Considering these machines historically, the first fact that meets our attention is that there exists a general and deeply-rooted idea that direct current dynamos of very high potential are not at all practical. This unfavorable opinion is particularly strong in regard to the use of such machines for the transmission of power for any considerable distance ; in fact, such a system is considered to be almost out of the question. The actual historical and practical facts are that the high potential direct current machines were more extensively and successfully operated when the dynamo first came into general use about 1880 than any other type, either direct or alternate. Furthermore, their number and size have largely increased and the voltage at which they can be practically worked has been steadily raised until we now have sixty-light arc dynamos as the standard size of large machines, generating about 3000 volts and 10 ampères. Arc dynamos of 90-light capacity are also regularly made by several manufacturers, and 120 or even 125-light machines are built and used. I happen to know of one station where there are four arc dynamos rated at 125 lights each, which run every night with a load of from 100 to 105 lights. These machines must generate about 5000 volts each. No great practical or other difficulty is found in operating arc machines, except that of danger to persons, but this is merely due to the high potential and does not depend very much upon the type of machine or character of current. Nevertheless, when it is suggested to use direct currents in the transmission of power, we are usually told that nothing over 1000, or at the most 2000 volts, is at all practical. Why this decrepancy between the 5000 volts which are practically used in arc lighting and the 1000 or 2000 volts that are considered the limitation of such machines for power transmission? Perhaps the first answer to this question would be to say that the current is limited ; that when we have 5000 volts we cannot have more than 10 ampères, and if we want more ampères we must have less volts ; consequently the number of watts, which, of course, is the entire question in power transmission, is limited. For example, the machines which I cited and which are in practical and successful use are of 5000 volts electromotive force, generate only 10 ampères, and consequently have a capacity of 50 kilowatts, which is a small power, comparatively speaking, for power transmission, but is sufficient for ordinary arc lighting circuits. That, of course, is a fairly good explanation of why such machines are not applicable to power transmission. But is there any such limit as 10 amperes to the current? I myself always look with very much suspicion and doubt upon any such arbitrary limit as that. Experience has shown me that those arbitrary limits are usually imaginary. Now, it is a fact, however, that should be added to this historical consideration of the subject, that numerous attempts have been made to employ such machines for power transmission and other purposes, and it cannot be said that those attempts have been successful; in fact, it can be said that they have generally been unsuccessful, but that is merely a negative fact. Now, when we come to the actual construction of such machines, and that is really the only substantial point that I can bring before you, I have actual results, although I cannot say that there is any particular feature of such machines which is radical or which will insure their successful operation.

The first point, of course, is insulation. That must be above suspicion. The next point is the commutator, because although the commutator might be considered the first point, as a matter of fact we must have the insulation before we can operate the machine at all, even for a few moments. The commutator, of course, must have a number of sections. It must have a considerable thickness of mica insulation between the bars, more than is ordinarily employed; I should say a full sixteenth of an inch. On the end of the commutator, where there is much more than the ordinary voltage between the bars, we require very much more thickness of mica insulation or some other insulation than is ordinarily given.

The next point is the material for brushes, and I have found in that particular feature the most peculiar and important differences. In the first place, I consider that it is impossible to run an ordinary mica-insulated commutator with copper brushes at high potentials, the reason being that the film of copper which is worn off of the copper brushes by the mica is a sufficiently good conductor at that electro-motive force to carry many watts of current. At an electro-motive force of say 500 volts, for instance, which is that of the ordinary railway generator, we have no such difficulty, because even if we use copper brushes, the film of copper that is rubbed on to the surface of the mica would not carry sufficient watts to cause any trouble, but at 10,000 volts, with a difference of potential in the neighborhood of 100 volts between the bars, the amount of copper, even although it is an almost infinitesimal film, is sufficient to carry many watts of current.

I have found that with a potential of only 5000 volts, which I have experimented with, copper brushes could not be used for half a minute; the copper would work off on the mica and immediately produce a ring of fire all around the commutator. Naturally one would use carbon brushes in such a case, because the current is very small, comparatively speaking, and there is no reason why we should not use carbon brushes. In regard to carbon brushes, I have also found that hard carbon is better, for the reason that it does not produce a deposit or layer of carbon on the commutator which might produce the same effect as the copper does, but not to the same degree, because carbon is a much poorer conductor than copper; therefore carbon brushes, with a comparatively small area of contact and a fairly strong pressure, not very great, but sufficient to insure good contact, seem to be the proper working conditions.

The machines I have actually constructed are two. One was a small machine of one horse-power capacity, the armature being of the toothed type. Some persons may think that that is exactly wrong, but the results do not seem to show that it was. It was very perfectly insulated with mica, and wound with double silk-covered wire. The potential of that machine was intended to be 5000, and I have succeeded, by slightly raising the speed, in getting 5500 volts out of it. It had only 32 commutator bars. That machine is not, of course, a practical machine, but it did run for hours at 5000 volts, and for an hour and a half at 5500 volts.

The next machine, which is a much more practical machine, was of five horse-power capacity, and designed to generate 10,000 volts. It did generate 10,000 volts at a little below the calculated speed, and gave 11,000 volts at about the speed it was designed for, which was 1800. This machine had 108 commutator bars, a much more practical number for such a voltage. The current of that machine was intended to be between three and four-tenths of an ampère, which gives about its capacity. It must be remembered that these machines did not give their full capacity, owing to the fact that the wire is extremely small and therefore the percentage of copper in the winding is small. The current actually obtained from these machines was about two-thirds of their rated capacity. It would be unfair to deny the fact that there is a spark when we approach the current capacity of the machine, and I think at the full current capacity the spark would be too great.

Now, as to the application of these machines, I would say that the purpose to which I have applied them has been ordinary experimental work. For example, one of these machines at 3000 or 4000 volts will run a Geissler tube very beautifully. It will produce any of the so-called electrostatic effects, that is to say, effects produced by very high potential and small quantity. It will, for instance, act very much like an electrostatic machine or a friction machine.

Another purpose to which the machine is applicable is testing of insulation, and in fact, that is one purpose for which I made it. It might be asked, why not use a high potential transformer as being more convenient and not having a commutator? I answer that by saying that I do not think that is the same test. If the wire is exposed to a direct current strain, I do not think an alternating current test is proper. If a wire is subjected to a direct current strain, it should be subjected to a direct current test. If it is subjected to an alternating current strain, it should be subjected to an alternating current test. The other application is, of course, power transmission, and I would say that of course it is not necessary to have the total voltage generated by one machine. In any plant no one dynamo should constitute more than a comparatively small fraction of the total plant, and if you have five dynamos in a central station or power transmission station, there is no reason why they should not be connected in series as well as in parallel. Each machine can generate a few thousands volts, two to five, and the total voltage could be obtained by the propers connections of several machines in series.

MODIFICATIONS OF CARBON IN IRON.

By Professor A. Ledebur.

AS far back as the end of the last century the observation was recorded that iron which had been produced by fusion with charcoal contained carbon. It was soon afterward recognized, as the author took occasion to say recently before the Iron and Steel Institute of Great Britain, that this carbon in the iron was not always present in the same form, and that it consequently affected the behavior of the iron in different ways. Karsten, in his early time, distinguished between graphite and combined carbon, and he was of the opinion that this combined carbon must be a constituent of a true chemical compound with iron of atomic proportions—that is, of a carbide. He was unsuccessful, however, in his attempts either to produce or to separate this carbide. This classification, of Karsten's, of the total carbon in iron into two main modifications—graphite and combined carbon—formed, until quite recently, the basis adopted in all text-books relating to the metallurgy of iron, for the consideration of the mode of occurrence of the carbon, and of the influences which this element exerts on the properties of that metal. All analyses published in the first nine decades of this century, in which the analysts did not rest satisfied with determining simply the total percentage of carbon, gave, even then, only the two above-mentioned forms of carbon. This division was, however, completely valueless in the case of true steel—of metal, that is, that might be hardened—whose behavior was entirely different, according to whether it had been permitted to cool slowly or had been cooled rapidly by plunging in water. Its percentage of carbon remained in both cases unchanged. An examination made in the manner formerly in vogue only showed the percentage of the so-called combined carbon, and yet the hardened and unhardened or annealed steels showed greater differences than did those of many different metals. The first of four modifications of carbon was graphite. Although the true cause for the formation of graphite must be deemed to be the power possessed by molten iron of dissolving more carbon than the solid metal could retain in solution, yet this difference in the degree of solubility did not always exist in exactly the same ratio. It was determined by the percentage of other foreign substances, in addition to the carbon, that were present in the iron, and especially by the silicon present. Silicon formed a necessary constituent of gray pig iron, but only a brief period of time had elapsed since this important part played by the silicon had been recognized. A second modification of carbon, resembling graphite, was the temper-carbon. The name was chosen for the reason that this form of carbon was mainly formed during the prolonged heating of white pig-iron during the tempering process. A third modification of carbon, which had been known to metallurgical chemists for a somewhat long period, without having been properly appreciated, might be best named carbide carbon. As in the case of the formation of graphite, the formation of the carbide was influenced by the nature and method of the cooling. Slow cooling aided the formation of the carbide, and rapid cooling rendered it more difficult. The fourth of the modifications of carbon now known was termed hardening carbon. It was evenly divided or dissolved throughout the whole mass of the iron, the mother metal, and escaped as an unpleasant smelling hydrocarbon gas, even at the ordinary temperature, if the iron was dissolved in dilute sulphuric or hydrochloric acid.

STEAM PIPING AND EFFICIENCY OF STEAM PLANTS.

By William A. Pike, M. Am. Soc. M. E.

SOME recent experience with steam plants detailed in a recent paper before the American Society of Mechanical Engineers, has impressed the writer with the apparent lack of good judgment and the application of correct principles in the arrangement of the piping between boilers and engines. In many cases, every effort seems to be made to select the best engines and boilers for the particular purpose in hand, but when it comes to the question of connecting them with steam-pipes it would appear that it was thought that anything with a hole through it would do. Whether the piping is right or not, affects the economy, efficiency and safety of a steam plant more than most engineers seem to think, and the writer believes that poorly contrived piping is in many cases as detrimental to high efficiency as the use of the wrong type of engine or boiler would be. The following are, perhaps, the points that should be most particularly looked out for in the design of a system of piping:

(1) The piping and accessories should be so arranged that practically dry steam shall always be delivered to the engine.

(2) The steam should reach the engine with very little "drop" in pressure.

(3) The piping should be so planned and valves so placed that water cannot under any circumstances collect anywhere, except in places especially arranged for that purpose.

(4) Wherever practicable, and especially where more than one engine is supplied from one battery of boilers, the piping and valves should be arranged so that in case of accident to any part, it can be shut off without shutting down the whole plant.

These requirements are not offered as new or original, but simply as covering points often neglected, and as furnishing texts for this paper. The first requirement given above, viz., that the steam should reach the engine dry, is one often neglected, and the writer has in mind plants of considerable magnitude where absolutely no provision is made for drawing off condensed or entrained water except through the engine itself, and the not uncommon cases of broken cylinder heads and pistons testify as to the effect of such designs. In these days of efficient pipe coverings, of separators, steam loops and traps, there is no excuse for, but false economy in, allowing water to reach the engine. In connection with point No. 2, a plan for disposing of water, followed with good success, will be spoken of.

The effect, that an improper arrangement of piping has on the pressure with which the steam reaches the engine, is probably not as well known as it should be, and the principal object of this paper is to bring it to the attention of engineers, and to show how the evil has been remedied. The conditions of the case used in illustration were as follows:

There were ten single-acting engines, 16 x 27 x 16 inches, arranged on two sides of an engine room, and making 250 revolutions per minute. They were supplied by a number of boilers, and the steam from these first passed to a drum, 28 inches in diameter and 45 inches long, at the top of the boiler room and between two rows of boilers. From this drum separate 8-inch pipes ran to each of the five engines on the side nearest the boilers. At the time referred to, the other five were not connected. The average length of each 8-inch pipe was about 76 inches, and there were five right-angle turns and two valves in each pipe. On testing these engines it was found that there was a great difference between the boiler pressure and that at the engines. This difference varied from eight to twenty pounds, depending on the amount of work being done, and averaged fourteen pounds during usual work.

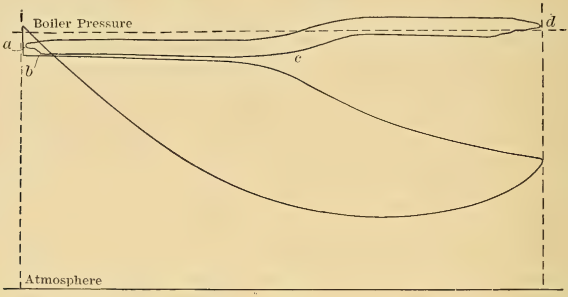


FIG. 1.—80 SPRING.

To find out, if possible something as to the reason for this drop, an indicator was placed in connection with one of these 8-inch feed-pipes, just outside of the throttle-valve, which was close to the engine. At the same time cards were taken from the engine, and Fig. 1 represents the result. The narrow diagram at the top is that taken from the pipe, while the lower one is a simultaneous diagram from the high-pressure cylinder. As will be seen, the steam is at the pressure *a* at the beginning of the stroke, and at admission falls suddenly to *b;* then during admission keeps nearly constant until complete cut-off at *c*; then the pressure rises to *d*, and gradually settles down to *a* again at the beginning of a new revolution. From these diagrams it can be seen that, as there is practically no steam-chest to these engines, and as they are single-acting and cutting off at about half stroke, there is a sudden and great demand on the 8-inch pipe during admission, a demand so great that the steam cannot keep up its pressure and, more than this, it appears that a vibration of the steam is set up in the pipe, causing the pressure to fluctuate from considerably below to somewhat above boiler pressure. This motion of the steam, of course, requires energy to be used up which is not therefore available for work in the engine.

In attempting to account for this last energy, the upper diagram has been treated as an ordinary indicator diagram, representing the work done in an 8-inch cylinder (the size of the pipe), and of a length equal to that of the volume of steam (in an 8-inch cylinder) required to supply the engine. Then, also, the loss due to friction is taken into account in the same way. The sum of these results is then compared with the extra work the steam would have done if admitted to the engine at boiler pressure. This last is shown in Fig. 2, in which the shaded part *AB* represents the additional work that would have been done if the steam had been at boiler pressure instead of having the admission line *a-b*, as was actually the case.

As an example, the case of two diagrams is taken, which were obtained simultaneously on October 21, 1892, at 9.20 A. M.: The area of the pipe diagram is 0.4 square inch; the length of the pipe diagram is 3.18 square inches; the mean effective pressure is 10.06 lbs.; and the length of an 8-inch cylinder, corresponding to the amount of steam used, is 3.0 feet. Then the work done $= Pe\ LAN = 10.06 \times 30 \times 50.26 \times 1 = 1517$ ft.-lbs. The pressure loss, due to friction, is estimated to be 2.19 lbs.; therefore the lost work due to friction $= 2.19 \times 50.06 \times 3.2 \times 1 = 330$ ft.-lbs or a total of lost work $= 1847$ ft.-lbs. The area added to the engine diagram, corresponding to *AB*, Fig. 2, $= .28$ square inch; the length of the whole diagram $= 3.3$ inches, and the lost mean effective pressure $= 6.79$ lbs. This pressure corresponds to 1819 ft.-lbs. per stroke. Thus we find from the pipe diagram and the estimated friction a loss of 1847 ft.-lbs., and the corresponding loss, as figured by the engine diagram, 1819 ft.-lbs., or an agreement within $1\frac{6}{10}$ per cent.

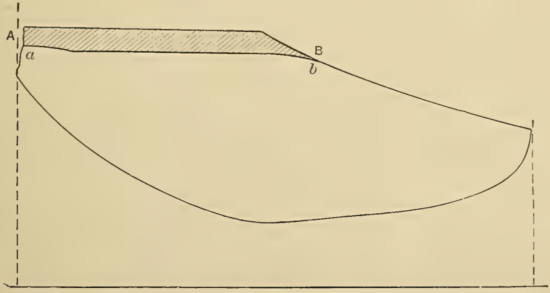


FIG. 2.

This analysis is added as an attempt to account for the loss, and, whether correct or not, does not affect the fact that in this method of piping there is a serious loss of pressure, causing a corresponding decrease in efficiency. As in this case the "drop" was so great, it was considered desirable to endeavor to prevent it.

Two plans were suggested, as follows: First, when the amount of steam used was considered, it was seen that, owing to the fact that the engines were single-acting, the demand while it lasted (with a cut-off of $\frac{1}{2}$, say $\frac{1}{4}$ of the time of a revolution) was excessive for n 8-inch pipe, though all available data would show the pipe amply large for a uniform flow of that amount, and so the first idea was to enlarge the pipe, still piping separately to each engine, with the design of reducing the effect of break-downs. But the same reasoning led to the fact that an 8-inch pipe would be amply large if the flow could only be made practically uniform. This led to the second plan—viz., to place a reservoir for the steam close to each engine, and thus enable the flow through the 8-inch pipe to be more nearly uniform. In order to get information as to such a plan, the arrangement shown in Fig. 3 was extemporized.

The 8-inch pipe leading to engine No. 2 was cut, and a drum 3 feet × 5 feet put in close to the engine; from this drum, a 10-inch pipe led to a 14-inch pipe, about 13 feet long on the floor, and from this, 8-inch pipes led to engines 1, 2, 3. The object was to get the effect, on drop of pressure, of receivers fed by one 8-inch pipe when supplying one, two or three engines. Much to the satisfaction of the experimenters it was found that when engine No. 2 alone was supplied through the drum, the drop was but a trifle over 1 lb.; that when two engines were fed the drop was a little over 2 lbs., and when all the three were supplied by one 8-inch pipe, through the receivers, the drop was about 5 lbs. These results confirmed the theory that an 8-inch pipe was easily ample for two engines without excessive drop, and that, when supplying three engines in this way, the drop was but little more than a third of that when but one engine was fed by a single 8-inch pipe without receivers. With this data as a basis new piping was designed for the plant, as follows: An extra drum was put in the boiler-room, and both drums were connected with mutable valves to a loop of 8-inch pipe, running past each of the engines on the side nearest the boiler-room, with a drum, 3 feet × 5 feet, between this pipe and each of the engines. The nipples connecting the drums with the engines project about a foot into the receivers, as shown by the dotted lines in Fig. 3, as separators for entrained water. Also each receiver was connected with a "steam loop," to carry this water back to the boilers. On the farther side a similar plan was followed, except that the loop was made of 10-inch pipe on account of the greater distance from the boilers. All pipes and drums were covered with an asbestos, air-space covering, and valves were placed between each pair of engines to allow of shutting off any part in case of a break-down, without shutting down the rest of the plant. Tests made of this system show a drop of only 2 lbs. on the farther side of the engine-room, when all five engines were under full load and fed by one loop of 10-inch pipe, making a complete circuit from the drums back to the drums again. The combination of "steam loops" and the separator drums is the plan referred to under the heading with reference to dry steam. This has worked admirably, there being no signs of water in the engines as there had been before.

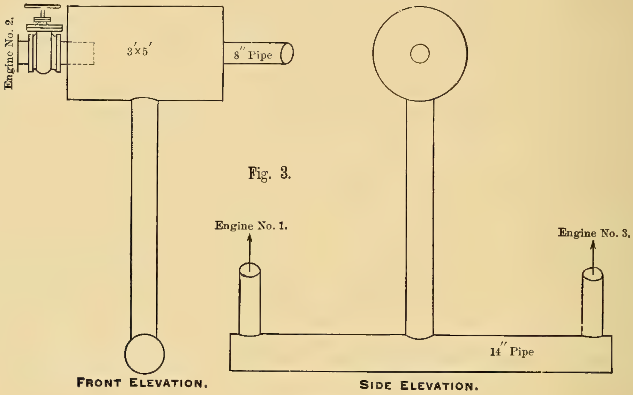


FIG 3.

(3) The danger that may arise from having piping and valves so arranged that water can collect anywhere except in places specially provided, can be best shown by two cases within the knowledge of the writer.

A. A battery of boilers was connected with a header, as follows: From each of two boilers a short pipe was led up to a horizontal pipe branching to the right and left to another pipe leading to the header. Valves were placed close to each boiler, but none at the header. At one time two of these boilers were shut down and the valves at the boilers closed, the remainder of the battery being in service. The first thing noticed was that the calorimeter in the header showed much drier steam than there was any reason to expect, and on investigation it was found that the branch pipe between the two boilers and the header was acting as a condenser and separator and became filled with water. This was fortunately noticed in time, and the water drawn off and a circulation kept up in the pipe, after which the calorimeter showed normal moisture and no harm was done, but if this body of water had been in any way set in motion the effect on the piping, which in this case was of cast-iron, can be imagined.

B. In the second case there was a steam main leading from boilers to various pumps, engines, etc., and at a certain point a temporary pipe was led into this main from another boiler with no valve between the pipe and main. Steam was admitted to this pipe for some reason, and then after a few minutes shut off, and steam let into the main. Shortly after this, steam was again admitted to the temporary pipe, and very shortly a "slug" of water passed from this pipe to the main, and acquiring a high velocity flew to a dead end and blew it off, causing the death of an employee. There seems to be no doubt that a valve placed at the intersection of the main and the temporary pipe, with a suitable "bleeder" in the pipe, would have prevented this accident, if handled properly.

(4) The necessity of arranging piping so that in case of accident only a part of the plant requires shutting down needs no argument, as the loss and annoyance due to shutting down a large plant, especially one on which the public in any way depends, as in the case of a lighting or street railway plant, is much greater than the expense involved in making such a thing impossible. The system followed in the case cited under the second head, is one that, while expensive, makes it impossible for any large part of the plant to need shutting down. The valves between the boilers and drums in the boiler-room, combined with those in the pipes from the drums and those between the engines, make it possible to cut out almost any part without materially affecting the rest.

HENRY DAVEY.

THE term *nascitur non fit* applies to other occupations besides that of the poet. Early associations may do much to stimulate, and education do still more to train, but to render the operations of these complete, there must be the innate capacity, without which neither artist nor mechanician, any more than the poet, can be made.

These remarks apply with singular appropriateness to Mr. Henry Davey, whose portrait is given in this issue. He is emphatically a born engineer, not merely because of the profession of his father, who had an extensive practice in Devon and Cornwall, Scotland, as a civil and mining engineer, but on account of the early aptitude which he showed for working in woods and metals, "making something," in fact, at an age when sweetmeats are usually more sought after than science.

Mr. Davey, who is still in the prime of life, served his apprenticeship with Messrs. Nicholls, Williams & Co., now Joseph Mathews & Co., in the pleasantly situated town of Tavistock, where he had a wide insight of the special branch of engineering pursued by his employers, on leaving whom he was engaged for a short time by a firm in the south of England to design portable and horizontal engines, proceeding afterward to London, where he remained for some years, occupied in the designing and erection of hydraulic machinery. In 1869 and 1870, he was connected with hydraulic and railway works at Milford Haven, and in 1871, he took out his first patent for the differential pumping engine with which his name has since been so honorably and successfully associated. A year later, in conjunction with his partners, he acquired the business of Messrs. Carrett, Marshall & Co., Sun Foundry, Leeds, and from these works have been turned out large quantities of machinery which are usefully employed in all quarters of the globe.

The invention of the differential expansive pumping engine may be said to mark a distinct era in the history of pumping machinery as applied to mining requirements. Probably the best certificate of the practical efficiency of Mr. Davey's pumping engine is found in the fact that it has been adopted for many of the largest mining and waterworks operations in Great Britain. Before Mr. Davey introduced his compound differential engine there were very few expansive working engines in the coal mining districts, and the pumps were usually bucket pumps with necessarily low lifts. Mr. Davey designed and introduced the double acting ram pumps for high lifts and succeeded in employing pumps to raise water in one lift to heights never before attempted. This was effected, not only by means of an improved engine, but also by improved pumps and pit work. The "separate" condenser for pumping and winding engines was Mr. Davey's, as was also the hydraulic pumping engine, now so largely employed for draining the dip workings in mines.

One of the many noteworthy plants installed by Mr. Davey's firm was an hydraulic pumping outfit for draining a colliery near Marseilles. The portion of the workings to be drained was subject to periodical inundations, which rendered the employment of underground steam engines impossible; neither could pumps be used in the shaft in which were pump rods and winding cages. In order to overcome these difficulties, Mr. Davey designed a scheme of hydraulic transmission from the surface. In the gallery subject to inundations were placed two hydraulic pumping engines, delivering the water which they pumped into the drainage gallery of the mine some distance below the surface. At the surface of the mine was placed a compound condensing pumping engine, working two double acting pumps from which water was conveyed, at a pressure of forty-two atmospheres, direct to the hydraulic pumps. The water supplying the hydraulic pumps was not discharged into the mine, but returned through a second pipe to the pumping engine on the surface. The water which actuated the hydraulic engines, therefore, simply circulated through the system. There is, of course, a back pressure on the hydraulic engines due to the vertical head of water in the return pipe, but the effective pressure is that which is produced by the pumping engine on the surface. In Sir William Armstrong's system of hydraulic transmission, the pumping engine delivers its water into an accumulator, from which the power is distributed. The accumulator is introduced to store the power of the prime mover, and to meet the interrupted demand for power caused by the intermittent use of the hydraulic machinery. In the case of the French installation just referred to, the use of the hydraulic pumps was constant; there was no object or necessity for storing power; the main *desideratum* was to cause the hydraulic pumps to respond directly to the motion of the engine on the surface, so that the speed of the engine on the surface should give the speed at which the hydraulic engines were working underground. It will be understood that if the pumping engine on the surface delivered a constant stream, and the hydraulic engines below used a constant stream, there would be no necessity for anything between the two engines more than a pipe. But both engines had a reciprocating action, and produced an intermittent stream in the pipe. To correct this intermittent action, and to preserve a constant pressure, and to maintain the engines working in unison, Mr. Davey devised a steam regulator which also served the purpose of a governor on the engine. A similar plant, but on a smaller scale, has recently been put up by Mr. Davey at the Grimesthorpe Colliery, Sheffield.

Mr. Davey's inventive talents have been by no means limited to the perfection of the differential pumping engine. Amongst other departures for which he is responsible is one which, though less pretentious than the differential pumping engine, is nevertheless of vast importance to rural communities and country houses. It takes the form of a system of water supply, the chief factor in which is the motor used. This motor is a vacuum engine designed on the most simple lines. Its power is derived from the condensation of steam at atmospheric pressure. It possesses a small generator in which the pressure is no greater than that in an ordinary tea kettle. The vacuum is produced by means of a small supply of cold water which may be used over and over again. In working the motor, no attention is required for anything but the fire, and that only very occasionally. An adaptation of this system is applied to the requirements of lighthouses and lightships for fog signaling purposes, and in whatever way the system is employed it is claimed to be cheaper, less liable to get out of order, and more easily managed than are either gas or hot air engines.

A recent invention of Mr. Davey's is a compensating compound and triple expansion pumping engine for town water supply. In this engine an ingenious method is employed to enable the engine to fully utilize the expansive force of the steam by bringing the force of the engine to bear on the resistance of the pump by means of a varying lever. Several large engines have already been erected on this plan, and very high performances have been obtained with them. Mr. Davey has also, in connection with his water-works designs, developed a system of pumping from bore holes.

Besides directing the Sun Foundry at Leeds, Mr. Davey has a considerable practice at London as a consulting engineer. He has, also, for a long time, been a voluminous contributor to public information on engineering and scientific subjects. He has read many papers before the various societies of which he is a member, and has also contributed to technical journals on various occasions. He is a prominent member of the Institution of Civil Engineers, and also of the Institution of Mechanical Engineers. He is further a Fellow of the Geological Society, and a member of the Society of Engineers, Society of Arts and Royal Institution. He has on numerous occasions read highly commendable papers before these bodies, and has also taken an active interest in the Yorkshire College of Science, of which he was, before leaving Leeds, a member of the Council.

THE COST OF STEAM POWER.

By Professor W. Cawthorne Unwin.

SIR F. BRAMWELL, in an address to the Institution of Civil Engineers in 1885, indicated very clearly, in a convenient phrase, those conditions involving waste of fuel in steam power production which are avoided by central station working. He said that we were "every day becoming more alive to the benefit where little power is required, or where considerable power is required intermittently, of deriving that power from a central source." Where little power is required the steam engine is costly, uneconomical, and inconvenient. Where great power is required intermittently both engines and boilers work in conditions extremely unfavorable to economy. Bearing directly upon this subject, the several tables, presented herewith, are of interest. They formed a part of a lecture on "The Development and Transmission of Power from Central Stations," delivered by the author a few months ago before the Society of Arts of Great Britain.

Table I., on the opposite page, gives a careful selection of results of steam engine experimental trials. In such trials it may be assumed that everything is working at its best, and that the steam and coal consumption is the smallest realizable with different engine and boiler plants. In all these trials the engines were worked with, at any rate, an approximation to the most economical load. It will be seen that the steam and coal consumption is less for large engines than for small engines; less for quick engines than for slow ones; and less for compound and triple engines than for simple engines. Even under favorable test trial conditions, and with an economical load, there is considerable variation in the amount of coal and steam required per horse-power.

Taking the most favorable results which can be regarded as not exceptional, it appears that in test trials, with constant and full load, the expenditure of steam and coal is about as follows :

Kind of Engine.	Per Indicated Horse-Power Hour.		Per Effective Horse-Power Hour.	
	Coal. lbs.	Steam. lbs.	Coal. lbs.	Steam. lbs.
Non-condensing	1.80	16.5	2.00	18.0
Condensing	1.50	13.5	1.75	15.8

These may be regarded as minimum values, rarely surpassed by the most efficient machinery, and only reached with very good machinery in the favorable conditions of a test trial. It is much more difficult to get the consumption of coal by engines in ordinary daily work. What is known shows that the consumption is greater than in engine trials. Some comparatively large pumping engines which work with a steady load night and day, and which worked with two pounds of coal per effective or pump horse-power on a test trial, used 2.7 pounds in ordinary working. The consumption was measured over many weeks, during which they were working ninety per cent. of the whole time. Here the consumption is thirty-five per cent. greater in ordinary work than in a test trial. The large pumping engines of the Hydraulic Power Company at London are less favorably circumstanced for

TABLE I.—*Coal and Steam Consumption in Steam Engines in Special Trials.*

		Authority.	Indicated Horse-Power.	Boiler Pressure. Pounds per Square Inch.	Piston Speed. Feet per Minute.	Steam per Indicated Horse-Power per Hour. Pounds	Coal per Indicated Horse-Power per Hour. Pounds.
NON-CONDENSING ENGINES.	SIMPLE.						
	Semi-portable	Unwin	5	61	263	65	6.5
	Small Brotherhood	....	13	....	....	41	....
	Small double-acting	Donkin	6	35	211	44	[5.0]
	Willans slow	Willans	9	44	200	41.8	....
	“ “	“	20	112	224	30.2	....
	“ fast	“	16	36	394	42.8	....
	“ “	“	26	74	409	32.6	....
	“ “	“	34	122	406	26.0	....
	Reynolds-Corliss	Hill	137	97	602	23.9	2.4
	Harris	“	134	96	606	22.0	2.2
	Wheelock	“	140	96	608	24.9	2.5
	COMPOUND.						
	Willans slow	Willans	10	84	122	27.0	....
	“ “	“	11	103	123	24.7	....
	“ “	“	13	120	131	23.4	[2.6]
	“ fast	“	33	114	403	21.4	....
	“ “	....	36	135	406	20.4	....
	“ “	....	40	165	401	19.2	[2.1]
	TRIPLE.						
	Willans	Willans	39	172	400	18.5	[2.1]
CONDENSING ENGINES.	SIMPLE.						
	Beam pumping, jackets.	Mair	123	42	223	22.0	[2.5]
	“ “ “	“	120	45	240	21.3	....
	Corliss, jackets	Longridge	488	61	520	19.3	[2.1]
	“ no jackets	“	508	60	520	19.8	....
	Harris-Corliss	Hill	166	96	606	19.4	1.9
	Reynolds-Corliss	“	163	96	603	19.5	1.9
	Wheelock	“	158	96	596	19.3	1.9
	Sulzer, jacketed	Linde	395	75	272	19.7	....
	“ “	“	284	87	372	18.4	....
	COMPOUND.						
	Semi-portable	Unwin	6	101	....	35.7	4.1
	Tandem mill	Donkin	57	53	....	20.5	1.9
	Tandem pumping, no jackets	Mair	177	70	692	20.9	....
	Receiver pumping, jkts.	“	127	61	264	14.8	....
	Worth'ton pump, jkts.	Mair & Unwin	296	75	124	17.4	....
	“ “ “	“	255	60	121	17.7	1.78
	Tandem mill, no jackets.	Longridge	888	87	442	17.8	1.78
	“ “ “	“	862	87	442	19.8	2.15
	Receiver mill, “	“	314	95	478	17.0	1.96
	“ “ jackets	“	338	95	487	17.2	2.04
	Beam pumping, jackets.	Leavitt	252	99	237	13.9	....
	“ “ “	“	290	99	241	14.2	....
	Sulzer, jackets	Sulzer	267	90	690	14.0	[1.6]
	“ “	Uincotte	135	90	395	15.3	....
	“ “	Soldini	272	110	590	15.3	....
	TRIPLE						
	Sulzer, jackets	Sulzer	360	145	....	11.7	....
	“ “	Schröter	198	156	460	12.2	....
	Maschinenfabrik (Augsburg), jackets	“	700	145	596	12.45	.. .
MARINE ENGINES	COMPOUND.						
	Fusiyama, no jackets	Kennedy	371	57	306	21.2	2.66
	Colchester, no jackets	“	1,979	81	522	21.7	2.90
	TRIPLE.						
	Meteor, jackets	Kennedy	1,994	145	574	15.0	2.01
	Tartar	“	1,087	144	490	19.8	1.77

economy. They gave an indicated horse-power on trial with 2.19 pounds of coal per hour. In ordinary work they are stated to use 2.93, or about thirty-five per cent. more. These engines have a fairly steady load during the day and a smaller load at night. If such a case as that of an electric lighting station is considered, where the load fluctuates very greatly, the maximum load being often four times the mean load, and the minimum load one-twentieth of the mean load, then the consumption per horse-power is very much greater. Mr. Crompton has given figures for the Kensington station, which has excellent Willans compound non-condensing engines. Those engines will work with less than two pounds of coal per effective horse-power in trials at full load. The results obtained in ordinary workings are given in Table II.

TABLE II.—*Engines in Electric Central Stations.*

Year.	Coal Used in Pounds Per Hour.		
	Per Electrical Unit Generated.	Per Effective Horse-Power.	Per Indicated Horse-Power.
1886	12	8.4	6.5
1890	8	5.6	4.35
1892	7	4.9	3.8

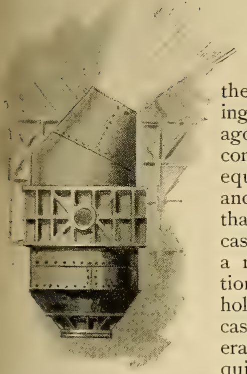
TABLE III.—*Coal Consumption per Indicated Horse-Power in Small Engines.*

Nominal Horse-Power.	Probable Indicated Horse-Power at Full Load.	Actual Average Indicated Horse-Power during the Observations.	Coal Consumption in Pounds per Indicated Horse-Power per Hour during the Observations.
4	12	2.96	36.
15	45	7.37	21.25
20	60	8.20	22.61
15	45	8.60	18.13
25	75	23.64	11.68
20	60	19.08	9.53
20	60	20.00	8.50

Instances are known of coal consumption at electrical stations still larger than any of these. Probably up to the present the consumption has in no case been less than six pounds per unit generated, 3.8 pounds per effective horse-power, or 3.3 pounds per indicated horse-power. This large consumption can be traced to two classes of waste, engine waste and boiler waste, due both of them to the inefficiency caused by variation of load. The latest British Board of Trade returns from electric lighting stations confirm these figures. Taking the largest and best stations, the consumption of coal varies in different cases from seven pounds to twelve pounds per unit of electricity generated. It is more than this per unit sold. In the case of small isolated motors, not generally of very good construction or well proportioned for their work, still more extravagant results have been observed. Table III. gives some results obtained with small workshop engines in Birmingham. These last results are interesting only for this reason, that it is such uneconomical small engines which are displaced when central station power distribution is introduced. It is because these small engines are so extravagant that power can be distributed from a central station at a profit.

STEEL CASTINGS.

By H. L. Gantt, M. Am. Soc. M. E.



WHEN we remember what the ordinary steel casting was, a few years ago,—a rough chunk composed of about equal parts of steel and holes,—and note that to-day a steel casting is subjected to a more rigid inspection for cracks and holes than an iron casting, while the general appearance is required to be nearly as good, we are forced to admit that a great advance has been made.

In a paper on the subject, outlining recent progress in the manufacture of such castings, and presented at the recent annual meeting of the American Society of Mechanical Engineers, the author took occasion to point out that the first soft steel castings, such as are used for gun carriages, that were made in this country, and which were subjected to a ballistic test, were made in 1886 and 1887, by the Midvale Steel Company, who were the pioneers in this work. The ballistic test was considered severe at that time, but to-day the ordinary soft castings made by almost any one of a dozen of the best steel casting companies would pass it successfully.

Although it was about 1886 or 1887 before any large increase took place in the use of steel castings, they had been successfully made in this country at least as early as 1867. In July of that year, the Wm. Butcher Steel Works, now the Midvale Steel Works, cast some crossing frogs of crucible steel for the Philadelphia and Reading Railroad. The molds were made of ground fire brick, blacklead crucible pots ground fine, and fire clay, and washed with a blacklead wash. The surface of these castings was very smooth, and the metal, which was practically tool steel, was so well adapted for the purpose that some of the castings made in those early days are said to be still in use. This was before the use of silicon for solidifying steel was known, and the castings were very much honeycombed in all parts except the wearing surface of the frogs, which was "cast down." The possibility of getting one face of a casting approximately solid admitted of the use of steel also for hammer dies, although their general sponginess was a great obstacle to their extensive adoption.

On April 28, 1876, two small hammer dies were made of open hearth steel at the same place, and on May 29th a hammer head weighing 2535 pounds was made. As long as castings were small, the molding mixture of ground brick, ground pots, and fire clay was satisfactory; but on large castings made with that facing, the surface was very imperfect, and the sand adhered to it with great tenacity. Little improvement in the method of molding was made for some time, and while the quality of the steel was gradually improved, the appearance of the castings was decidedly against them, and slow progress was made in their introduction.

The next step taken by the Midvale Steel Company was to leave the ground pots out of the molding mixture, and to wash the mold with finely ground clay fire brick. This was a great step in advance, especially in heavy castings, and a marked improvement took place in their general appearance; but the mixture still clung so strongly to the casting, that only comparatively simple shapes could be made with certainty. A mold made of such a mixture became almost as hard as fire brick when dried, and offered so much resistance to the proper shrinking of castings that, when at all complicated in shape, they had so great a tendency to crack that their successful manufacture was almost impossible. The next step was to use a mixture of silica, sand and flour. In small castings this gave pretty good results, as such a facing cleaned off the casting very readily, leaving a smooth surface, much superior in appearance to that left by the ground brick. The great difficulty in the way of the extended use of such a facing was the tendency of the flour to burn in drying, leaving the sand without a proper bond, and often the burnt mold was so friable as to be entirely useless. In the case of large castings it was almost impossible to dry thoroughly the whole mold without burning that portion nearest the fire, and for such work flour was necessarily abandoned.

By this time the use of silicon for solidifying castings was coming into general use, and the only obstacle in the way of making good steel castings was the want of a suitable molding sand. This was ultimately found in a mixture, the principal constituents of which were silica, sand and molasses, thoroughly ground together.

The improvement in the appearance of castings caused by the use of a sand that left a clean, smooth skin was the cause of their rapid adoption, and the year 1887, when the Midvale Steel Company made the first gun carriage castings of steel, is approximately the date at which their rapid extension began. At this time the necessity for hot metal did not seem to be understood, and castings frequently contained "blow holes," when it seemed that all the conditions for making them perfect had been complied with. It was noted, before a great while, that small castings contained more holes than large ones, and that those poured last on a heat were worse than those poured first. The conclusions that hot metal was needed to make solid castings, and that smaller castings needed hotter metal than large ones, were soon deduced and amply verified. Apart from these considerations, the superior appearance of castings made from hot metal was sufficient to cause all steel casting makers to work in that direction. The difficulties in the way of getting uniformly hot metal are hard to overcome in an open hearth furnace. The delay caused by a slow or difficult tap of the furnace, which is always liable to occur, is fatal to the production of the best castings.

Besides what has already been mentioned, "cold metal" in the ladle is to-day the cause of more complaints by purchasers, and expense to the manufacturer, than anything else in connection with the manufacture of steel castings. I will enumerate a few of the troubles that may be traced directly to this cause. What is known as a "bad shut off," or a leaky stopper, is usually caused by a small amount of metal chilling in the nozzle, and preventing the stopper from going to its place. In cases where the dribble is slight the worst effect is that a small amount of metal runs into the mold while the ladle is being gotten over the runner. This metal is apt to chill, and make a bad looking spot on the casting, or, in the case of small castings, block up the runner entirely, and cause the loss of the mold. When the leak is very bad, it not infrequently happens, especially when the heat is a large one, composed principally of small castings, that the flasks are covered by the molten steel and so strongly fastened together that it is almost impossible to separate them from the steel without considerable loss by breakage. Again, by a careful study of the subject, I feel that I have been able to lay to the door of "cold metal" one of the most fertile sources of complaint which steel founders have met with; namely, lack of homogeneity, which includes both "hard spots" and "loose" places. I use the term "loose," rather than "spongy," for the reason that I do not so much mean a cluster of holes, as a spot where the metal simply seems less dense. Such places, without any visible continuous hole, or even without anything that would indicate the existence of such a hole, allow leaks in hydraulic cylinders, and cause the failure of a test bar.

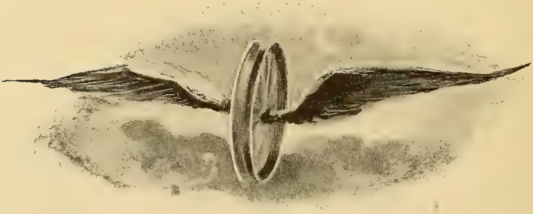
When we consider more in detail the process of making open hearth steel castings, we see why these defects are more apt to occur in cold than hot metal. While the metal is being tapped from the furnace, the silico-spiegel necessary to prevent "blow holes" is generally thrown into the ladle, usually in the solid, though heated, state. If the metal is very hot, and consequently thoroughly fluid, the silico-spiegel is dissolved at once, and uniformly disseminated through the mass. If, however, the metal should not be so hot, it is easily seen that the silico-spiegel may not become at all thoroughly diffused, and the slightly viscous metal in the ladle may be the reverse of homogeneous, in which case the resulting castings may be very far from what is hoped for. It is now the practice, in the best foundries, to melt the silico-spiegel, and these defects in their worse form are thus practically eliminated.

Why hard spots should appear in cold metal is readily seen, for lumps of partially melted silico-spiegel would certainly form the nuclei for such spots; but why the "loose" places should occur is not quite so apparent. It may be noted that the loose places appear to a more marked extent in large masses than in small ones, and the most reasonable explanation seems to be that the silico-spiegel, which is but imperfectly melted when the metal is poured, finally melts thoroughly after the metal is in the mold, which can only occur in very heavy castings, forming a spot higher in carbon, manganese, and silicon than the metal surrounding it. Such a spot would have a lower melting temperature than the adjacent metal, and would remain partially fluid after the other metal was set. The result of such a condition would be to drain away a portion of the fluid metal to feed the shrinkage n the metal solidifying about it, leaving a more or less spongy spot. That shrinkage holes and cracks do still occur in steel castings is well known, but the success that founders have had in casting complicated shapes within the last year or two has been surprising. The fact that a steel casting must cool at the bottom first, and then gradually upward in the mold, is being learned by designers, and shrinkage holes are becoming less frequent, for the founder at once fixes on the heaviest portion for his sink head, which is usually about twenty per cent. of the total weight of the casting, and which must remain fluid until the whole of the casting proper is solid.

By a strict observance of the rule that a steel casting should, as far as possible, be of uniform thickness throughout, it has been possible to make, within the past few years, castings twenty feet long by ten feet wide, which would have been considered impossible a few years ago. To one unfamiliar with the details of the process of making steel castings, the statement that to-day we can get large steel castings that are perfectly satisfactory, while it is almost impossible to get good small ones, would seem very strange. It is, however, a fact, and the explanation is simple. Most steel castings are made by the open hearth process, and the furnace usually melts from five to twenty tons. To pour even five tons of steel into castings averaging 100 pounds in weight would, as a rule, take so long, that those poured last would be of inferior quality on account of the cooling of the metal. As a rule, a large portion of the heat is poured into a comparatively few large castings, and the remainder put into the smaller ones. If the metal is very hot to start with, this may give fair results, but in all cases the least desirable metal is put into the small castings.

This difficulty seems almost insurmountable by the open hearth process, but is readily overcome by a small Bessemer converter, from which we can get two or three tons of metal as hot as we may wish it. Add to this the fact that we can get from the converter that quantity of metal of any composition desired, every half hour throughout the day, and we realize the advantage of the Bessemer process for making small and medium weight castings. The manufacturers of electric motors who have been buying their castings from open hearth foundries have apparently not realized what the Bessemer foundry has in store for them. The fact that we can make a number of different kinds of steel each day if we use a converter, and but two or three heats at most in twenty-four hours if we use an open hearth furnace, gives a great advantage to the founder using the converter, especially if he is making all kinds of steel castings, enabling him, as a rule, to make far more prompt deliveries than is possible for the open hearth founder doing the same variety of work.

Among the other advances made in casting steel may be mentioned one for making a casting having one or more faces of a steel much harder than the body of the casting. The process consists in lining such faces of the mold as will be adjacent to the parts of the casting which it is desired to harden with a metallic alloy in a crushed or powdered state, capable of being melted and absorbed by the molten steel in contact with it, and of such a nature as to impart to the steel a hard face, or a face of such a composition as may be readily hardened. If it be desired that the casting shall have a permanently hard face and be used for stamp shoes, crusher jaws, hammer dies, etc., ferro-manganese give the best results. If it be desired to do machine work on the face, and make it extremely hard afterward, ferro-chrome is most suitable. The fact that it is possible to produce a soft steel casting, having a face that can be hardened without causing the remainder of the casting to become brittle, will undoubtedly make it possible to use steel castings instead of chilled iron in many places with great advantage.



Current Topics.

THOSE who are interested in the saving of coal wastes and the suppression of particularly smoky factory and other chimneys will find some rather suggestive figures in the report on the mineral industries of the United States, showing what enormous quantities of coal are annually consumed in the different cities of the country. New York, for example, in 1889 received for consumption a little more than 3,300,000 tons of anthracite, and over 1,850,000 tons of bituminous coal; for Philadelphia the respective amounts for the same year were about 3,190,000 and 920,000 tons; for Chicago, 1,450,000 and 3,220,000 tons; for Boston, 1,240,000 and 525,000 tons; and for Brooklyn, 1,800,000 and 200,000 tons. But even the smaller cities burn up coal at an impressive rate, making the total annual consumption mount up into a quantity so vast that even the smallest percentage of saving that could be effected would represent something remarkably substantial. Special forms of furnace grates, smoke consumers, mechanical stokers and damper regulators galore have been offered for years with claims of reducing coal consumption by varying fractions. Some of these contrivances are doing good work and are reaping the rewards of their merits in the shape of profitable sales, but they still leave a wide field in which ingenuity and invention may be exercised with every hope of handsome pecuniary returns.

ELECTRIC propulsion on canals, as depicted in these pages a month or two ago, is not altogether so new a thing as those who read of the Erie canal enterprise may have been led to think. For some time past, in fact, electric power has been applied to identically the same purpose in France, on the Canal du Bourgogne, and illustrations which have appeared in several French papers of the electrically equipped boats there used, have shown the arrangement adopted to be similar in many respects to that only recently carried out in the United States. On the French boats, however, the electric motors are not coupled to the propeller shafts, but, instead, drive trains of gearing by which a chain on the bottom of the canal is clutched, thus pulling the boats along. Chain haulage of this general kind has long been in use on some of the

European waterways and, in itself, is nothing new, simply illustrating in this instance another example of electric development of an old method of propulsion. The double-trolley system is employed, and the current is furnished by generators driven by turbines, the canal company controlling near-by water powers which could be readily utilized.

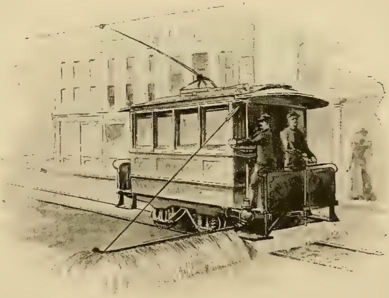
HIGH speed war ships are the order of the day. Those that only a few years ago were considered phenomena of swiftness have already been completely eclipsed and a vessel that, on trial, now develops 18 or 19 knots an hour is no longer regarded as anything particularly noteworthy. Twenty-two, twenty-three, and twenty-five knots are among the latest performances which have been actually attained by some of the recent additions to the United States Navy, and questioning comment and incredulous head-shakings alike, indulged in by some foreign engineers, have been unable to controvert the facts as set forth by the official records. After all, however, it is only just to bear in mind that these phenomenal figures are trial-trip figures, and no one fairly conversant with trial-trip conditions and naval practices the world over would, for a moment, suppose that such speeds are likely to be realized in the regular, every-day operations of the vessels which, for once, achieved them. Official speed-trials in all navies are made under exceptionally favorable conditions. There are picked crews of firemen, picked coal, and picked weather, if we may use that term, and every possible precaution is taken to get from the ship the best of which she may be capable. She comes fresh from the dry-dock, with a carefully cleaned bottom, the time duration of the trial is limited,—a four-hour maximum having been universally adopted,—and her performance may be likened, not inaptly, to the burst of speed of a race track courser, well prepared and exceptionally well handled, putting all its efforts to a task far above the average. Once through the trial, the ship, which has thus attained the rank of, say, a 20 or 22-knot vessel, often settles down to a plane of comparative mediocrity, in point of speed, and is rarely likely to be again called upon to practically demonstrate that she was at one time capable of doing that with which she has been credited by the Department records. Some qualification is, therefore, desirable when we speak of the speed performances of some of the new naval additions. It is only fair to presume, however, that a vessel which has developed high speed under trial will always be a swift vessel under ordinarily favorable conditions, measured by contemporary standards, and the new ships of the United States Navy may, therefore, well be regarded as among the foremost examples of what can be accomplished in this line by modern naval architecture applied to purposes of war.

THE U. S. CRUISER "OLYMPIA" RUNNING AT 24¼ KNOTS.

H. M. S. "VICTORY," NELSON'S FLAGSHIP, 1765.

Consolidating steel ingots by centrifugal force is being practiced at one of the Swedish steel works, the scheme being to subject the freshly-filled ingot mold to the pressure resulting from centrifugal action. The apparatus by means of which this is accomplished, and which has been devised by Mr. L. Sebenius, is described in Stahl und Eisen as consisting of an upright shaft in the centre of a cylindrical casting pit, carrying a frame of four arms, each of which has a platform supporting four ingot molds. While the shaft is at rest the molds are upright, and are filled in the usual way, but when it is set in rapid rotation they fly up into a horizontal position, and a pressure in the direction of the length of the ingot is developed, equal to about 30 times that due to the column of liquid metal in the mold. This drives the gases out and produces a perfectly solid casting. Uniformity of composition is also induced, as on account of the rapid cooling liquation is prevented. The process has been in satisfactory use for about two years at the Nykroppa Works, in Sweden. The circumference described by the bottom of the molds, when spun up into the horizontal position, is about 67 feet, corresponding, with the adopted working speed of 125 revolutions, to a velocity of nearly 10,000 feet per minute. The pressure on the mold taken at 30 times the depth of the ingots will be about 150 feet of iron, or from 500 pounds to 600 pounds per square inch. In the form of the apparatus intended for smaller ingots the molds are arranged on an inclined position and radially to a central fixed vertical feeding tube upon a turntable, which is set in rotation after filling, or the latter operation may be performed while the table is actually in motion. There is a later modification of the apparatus, in which the rotating table, being smaller in diameter than that previously adopted, can be driven at a higher speed, up to 200 revolutions per minute. There are eight pivoted molds, each divided by internal walls, so as to give nine small ingots suitable for wire billets or thin sheets. By means of a central annular funnel, lined with refractory material, and provided with eight feeding spouts, or one for each group of molds, the whole number of 72 ingots is cast by a single pouring from the ladle.

Street sprinkling on some of the street car lines in the western part of the United States,—at Louisville, Ky., and at South Chicago, for example—is accomplished in an ingenious manner by special sprinkling cars, an illustration of one of which, built by the United Tramway Sprinkler Company, of Louisville, is herewith appended. No special argument in favor of street sprinkling, and particularly of track sprinkling along dusty stretches of road, is necessary, and for years past street car lines in different parts of the country have sought to accomplish the track sprinkling by various contrivances, mostly bearing the stamp of being home-made, and consisting simply of large, boiler-iron tanks, mounted on rude platform cars, and provided with some kind of sprinkling pipe underneath. While these cars did their work in quite a satisfactory manner, they, of course, added nothing directly to the revenues of the companies operating them, but simply made traffic over the lines more comfortable and endurable to the passengers. More recently, however, it has been demonstrated that street sprinkling by car



SPRINKLING FROM A STREET CAR.

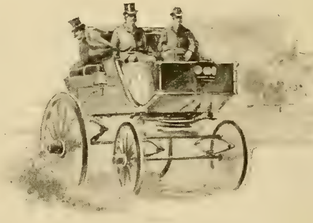
companies could easily be made a source of profit by having sprinkling cars that would not only sprinkle the track, but that would take the place of the ordinary street sprinkling wagons which have always derived desirable revenues from property owners. To this end, cars of the pattern shown on the preceding page have been turned out and operated to the entire satisfaction of all concerned.

THEY are similar in appearance to ordinary passenger cars. Double enders, for roads having no turnables, have an equipment of sprinkling pipes at each end. There are two pipes in each equipment, one to sprinkle the track, and another to swing out from sides of platforms where it has a swivel joint connection with a pipe from a tank, and sprinkles between track and curb. The amount of water thrown by this pipe is regulated by a sliding cut-off within the pipe. The pipeman by a crank lever readily swings this pipe to any desired position, from one lying parallel with the car beneath its overhanging sides, to a position at right angles to the car. This enables him to pass vehicles and obstructions, and sprinkle streets of varying widths with the same length of pipe. Flush hydrants are located between the tracks, from one-half to one mile apart, according to the width of street, and a connection is provided which enables the motorman and pipeman to stop, connect the filling hose with the hydrant, fill, disconnect and start in an average of less than two minutes. As the car stops only to fill, and can distribute at full speed, it is thus enabled to sprinkle streets on passenger train schedule. The capacity of the tanks is about 2000 gallons, and with the usual 5-inch connection and average city water pressure in the street mains, these 2000 gallons can be taken aboard in a few minutes. It has been suggested that even where a railroad company does not care to contract with property owners to sprinkle the entire street, although most companies could probably realize fair revenues by doing so, local companies might be formed for the purpose, thus relieving the roads themselves of all the work of making contracts and collecting bills, but insuring a regular rental for hauling the cars over their lines.

BOWS and arrows have recently been suggested as desirable adjuncts to city fire department equipments, the plea being made that if strong silk threads were attached to the projected arrows, and connected with cords, strong enough to carry a life line up to people in burning buildings, an important life-saving purpose might be accomplished. The thread, cord and rope, of course, would have to be saturated with some solution having fire-resisting properties. The scheme evidently was prompted by the successful use of life-lines, thrown in a somewhat similar manner in the life-saving service along the sea coasts, and recalls also some of the earlier practices of what were known as "steeple-jacks" for gaining access to the tops of church steeples and tall chimneys for the purpose of examination and repair. A kite was flown by a trained and skillful hand over the top of the structure to be climbed, on which generally upwardly-curved iron hooks were left fixed in a convenient position for catching the kite string. With the string once over one of these hooks, the kite was pulled down to the ground by a second string attached to the one which was used in managing and controlling the flight, in this way leaving the string looped over its aerial support. The kite being then removed, a stout cord was attached in its place and drawn over the top of the structure until the cord had taken the place of the string, rising from the ground, passing over the hook, and descending to the ground at the other side. This process was then repeated, stouter and stouter cordage being used each time, and finally a strong iron chain, until at length a tackle was raised and fixed from which the adventurous workman, or "steeple-jack," could be pulled up to complete the adjustments and attachments of more reliable machinery above. It need perhaps scarcely be observed that some skill was required for the attainment of distinction in this art of kite flying.

One great disadvantage of the process was the delay that continually occurred in getting the necessary adjustments made. A firm who had undertaken a work of reconstruction or repair naturally hesitated to send a staff of workmen to any distant place until there was good assurance that they could at once enter upon their task. A kite-flyer was, therefore, dispatched as a preliminary measure, to establish a practical connection with the top of the chimney or steeple. But when this forerunner was once well away from the superintending eye, it seldom happened that a favorable wind for the kite-flying part of the programme could be secured. The public houses in the neighborhood of the scene of operations, which naturally became the refuge of the kite-bearing artist and messenger, appeared to exert some very curious meteorological influence upon the direction and force of the air currents. Weeks, and in some special instances months, would slip by before a favorable and manageable breeze would present itself for raising the kite, adding a material item to the total expense of the undertaking. It was these embarrassing circumstances that ultimately led to other, now currently practiced methods, of climbing chimneys, independent alike of the caprices of the wind and the seductions of drinking places. For the past twenty-five years, in fact, the old kite process has probably been only rarely followed and may well be classed among the engineering relics of a bygone generation.

For several years past the application of electric storage batteries to the driving of ordinary road carriages has attracted attention, and repeated efforts have been made, principally in France, to bring vehicles, propelled in this way, into favor. The latest outcome of French enterprise in this field is a carriage, designed by Paul Ponchain, of Armentières, with which most satisfactory results are said to have been recently obtained. It has seats for six persons, and electric power is furnished by Dujardin batteries, arranged in six groups of nine cells each. Each group is contained in a box 12 inches high, 17 inches long and 13 inches wide, and each cell consists of one positive and two negative plates, mounted in an ebonite shell. The cells of each group are connected in series. The batteries are carried in a large box, coated with asphaltum, and careful provision has been made to avoid spilling the solution. A suitable controlling switch enables the making of various combinations among the batteries so as to make different working speeds possible. The motor is a Rechniewski machine of 2000 watts capacity, capable, in case of need, of developing double that amount of power for a short time. The power is transmitted to the rear carriage axle by link belts and sprocket wheels. Steering is effected by a hand wheel attached to a rod, the lower end of which moves the axle by means of bevel gearing. The electric measuring instruments, switches for lighting the three lamps with which the carriage is equipped, and a reversing switch are carried on the dash board. The service weight of the whole outfit is about 3000 pounds, and one charge of the batteries is said to be sufficient for a 44-mile trip on a paved street at a speed of about 10 miles an hour. M. Hospitalier, well known in French electric circles, takes a rather enthusiastic view of the capabilities of vehicles driven in this way and thinks that even before the end of the present century, Paris, at least, "will have


A FRENCH STORAGE BATTERY CARRIAGE.

become a paradise of electric coaches.'' A good deal, of course, depends upon the commercial aspect of the matter. Progress in storage battery development, however, has been encouraging during the past few years, and what may now seem to be somewhat extravagant claims may be more than borne out by actual performances a short time hence.

WHILE fly-wheel accidents are not yet quite so common as boiler explosions, there is a goodly number of them on record, and the destruction of property caused by each one that has happened within the past few years has amounted up into figures of considerable magnitude. One outcome of these accidents has been a flood of contributions to the technical journals, discussing fly-wheel stresses and design and various details of construction. Among these last is one of special interest, mentioned in a paper presented to the French Society of Civil Engineers several months ago. M. Chaudy, the author of the paper in question, after referring to the state of tension and the tendency to elongation of the rim of a fly-wheel under the influence of centrifugal force, pointed out that with the ordinary form of construction, in which there is a rigid connection between the spokes and the rim, the radius cannot increase at the ends of the spokes, except by the amount by which the spokes themselves extend. To obtain equal stress in all parts of the rim, it is necessary that the rim should be able to expand equally in all directions, retaining its circular form. For this reason, M. Chaudy proposes that the connection between the spokes and the rim should be a sliding connection, such as may be made by studs screwed into flanges on the ends of the spokes, and passing into smooth holes in the rim. M. Chaudy also objected to the ordinary form of spoke when a rigid connection is used, because in that case the bending stresses are greatest at the end of the spoke, while the section is always made least at the end. With the sliding connection the usual tapered spoke would be the correct form, as there would be no bending moment at the outer end. It remains to be seen whether anything will be done with this suggestion in a practical way. With the exception of Mr. Manning's wooden-rim fly-wheel,—the outgrowth of the disastrous accident at the Amoskeag Mills some time ago,—and several wire-bound fly-wheel rims brought out in Europe, there has been nothing unusual to record in the way of actual fly-wheel construction, though some things obviously remain to be done in that line that will tend to afford greater immunity from such serious mishaps as have latterly been recorded.

THOUGH wire-rope power transmission is now common enough, its best-known application being found in the many cable street railroads in operation in different cities, the origin of the system is less familiar. Engineering text-books generally state simply that the invention of telodynamic transmission, as it is preferably termed by them, is due to C. F. Hirn, a brother, it may be added, of the illustrious G. A. Hirn, to whom the engineering profession is so deeply indebted for his researches in the field of steam engineering. It is specially interesting to note, therefore, Professor Unwin's more detailed reference to the subject in his recent elaborate paper on ''The Development and Transmission of Power from Central Stations,'' read before the Society of Arts of Great Britain. In 1850, it appears, there were some large factories at Logelbach, near Colmar, in Alsace, which had been standing idle since 1841. It was a question of starting these again as factories for weaving, but there was only one steam engine, and the buildings were scattered at considerable distances. It occurred to Hirn to drive one of the factories, at a distance of about 260 feet from the steam engine, by a steel band, used like an ordinary machine belt, on wood pulleys about 6½ feet in diameter, and making 120 revolution per minute. This band was about 2½ inches wide, and $\frac{1}{24}$ inch thick and was used for 18 months, transmitting 12 horse-power. Then an English engineer, Mr. Tregoning, suggested the use of a wire-rope cable. A cable of $\frac{1}{4}$ inch in diameter was procured, and replaced the steel plate in 1852. The same pulleys were used, with a groove turned in the rim $\frac{1}{2}$ inch deep. That cable worked for years, the pulleys, however, being replaced by iron ones. A second transmission, to a distance of nearly 800 feet, was soon erected, with pulleys 10 feet in diameter, with a cable $\frac{1}{2}$ inch in diameter, running at a speed of about 50 feet per second, and transmitting 40 horse-power. Supporting pulleys were used at the half-distance.

THESE transmissions are still working. Hirn confessed that his chief difficulty at first was the construction of the pulleys. It was not till he adopted a pulley with a dovetailed groove filled with gutta percha, that he felt the problem of wire-rope transmission to be solved. With these pulleys, neither the pulley nor the cable suffered excessive wear. In 1854 Henri Schlumberger transmitted the power of a turbine over a distance of over 250 feet to drive agricultural machinery. In 1862, Hirn stated that he knew of more that 400 cases of wire-rope transmission. In 10 years, M. Stein, of Mulhouse, is stated to have constructed more than 400 such transmissions, carrying an aggregate of 4200 horse-power over an aggregate distance of nearly 24,000 feet.

IN connection with this subject, it is interesting to note what Mr. W. A. Roebling, of Trenton, N. J., who is prominently identified with the manufacture of wire rope, has to say, in a recent issue of the Bulletin of the American Iron and Steel Association, concerning some of the early wire ropes in the United States. It would appear from this that the first rope made in that country was turned out by John A. Roebling in 1840, at the village of Saxonberg, in Butler county, Pa. The rope was three-quarter-inch in diameter and perhaps 500 feet long, and was used on a subsidiary plane at Johnstown, in the same State. It was made of parallel laid wire, and served on the outside with annealed wire. This style of rope did not prove a success. The next rope was made for one of the inclined planes of the old Portage Railroad across the Alleghany mountains. The length of this rope was about 1500 feet, and its diameter, one and one-quarter inches. It was constructed on correct principles, substantially in the same way that wire rope is made at the present day. It lasted a long time and gave good satisfaction. Its success was the means of introducing wire ropes on the remaining nine planes of the Portage Road. Before wire ropes could be used on these plans however, it was necessary to rebuild the old inclined plane machinery, which was adapted only for heavy, thick hemp ropes. The hardest work was to overcome the opposition of the hemp rope interest. Mr. Roebling had been in the service of the State of Pennsylvania for several years surveying routes for the proposed railroad across the mountains. This gave him a very fair knowledge of the operation of the inclined planes, and resulted in his proposition to substitute wire ropes for hemp ropes. These planes were located in 1825-8 by one of Napoleon's generals. First, heavy chains were used, then hemp rope, and then wire rope. Canal boats in sections were taken over the mountains in this way. The planes were abandoned in 1851-2. The next application of wire rope on a large scale was on the planes of the Morris Canal, in Northern New Jersey, followed soon after by its adoption on the planes of the Delaware & Hudson Canal Company, Pennsylvania Coal Company, and others. In 1848, Mr. Roebling found that most of his business was in the East, and this fact led to the removal of his plant from Butler county to Trenton, N. J., where it subsequently developed into one of the most elaborate of its kind.

THE Franklin Institute, at Philadelphia, has long borne an honorable record for conscientious work in the promotion of the mechanic arts, and at this late date needs little advertisement of its merits. For a great many years its Journal has given to the public records of interest and value from engineering and scientific standpoints generally, disseminating information of the most useful kind, and has long since come to be looked upon as a publication of standard value. Withal, however, some of the good influences of the Institute have been exerted in so quiet a way that they are perhaps less known and less appreciated than they deserve to be. What has prompted these remarks is the announcement, recently issued by the secretary of the Institute, calling attention to the fact that the Institute may grant, or recommend the grant of, certain medals for meritorious discoveries and inventions which contribute to the promotion of the arts and manufactures. The character and conditions of these awards are briefly set forth in the circular, from which it appears that there are three medals at the disposal of the Institute. One of these, the Elliott Cresson medal, founded in 1848, by the gift of the late Elliott Cresson, is of gold, and by the terms of the deed of trust may be granted for some discovery in the arts and sciences, or for the invention or improvement of some useful machine, or for some new process, or combination of materials in manufactures, or for ingenuity, skill or perfection in workmanship. The John Scott legacy premium and medal, awarded by the city of Philadelphia, were founded in 1816 by John Scott, a merchant of Edinburgh, Scotland, who bequeathed to the city of Philadelphia a considerable sum of money, the interest of which should be devoted to rewarding ingenious men and women who make useful inventions. The premium is not to exceed twenty dollars, and the medal is to be of copper, and inscribed "To the most deserving." The control of the Scott legacy premium and medal, by act of the ordinance of councils in 1869, passed to the board of directors of city trusts, and has been referred by the board to its committee on minor trusts, and that committee has resolved that it will receive favorably the name of any person whom the Franklin Institute may, from time to time, report to the committee on minor trusts as worthy to receive the premium and medal. The third, the Edward Longstreth medal of merit, was founded in 1889, by Edward Longstreth, a late member of the Baldwin Locomotive Works. This medal is of silver, and may be awarded for useful invention, important discovery, and meritorious work in, or contributions to, science or the industrial arts. To those more particularly interested in the subject, the secretary of the Institute will be glad to give further information.

J. C. Henderson

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THE ECONOMICS OF ELECTRIC POWER.

By H. L. Lufkin, M. Am. Inst. El. Eng.

THE very interesting article by Mr. C. J. H. Woodbury, in the July number of this magazine, described several special applications of electric power, and also commended and predicted its much more general use in industrial power transmissions. These predictions the writer heartily endorses, and, to take possibly a step further into the electrical power field, and for the purposes of this article, he has gathered a mass of data covering some four or five thousand horse-power of electric motor applications, in order to determine, as nearly as average conditions will allow, the economic side of an electrical power transmission.

The ideal condition of transmission of power electrically, embodying, as it should, in each machine its own motive power, is slow of realization. The machine and tool manufacturer and the electric motor manufacturer must first get together and harmonize the designs of their apparatus to the end of simplification of details and application, and reduction of first cost. This condition accomplished, our large mills may be constructed at much less cost of building than is possible now, as all strains of shafting and belting on the building frame will be done away with, and this saving will surely more than pay any increased cost of electric tools and machines. Consider also the beauties of a shop equipped after the above ideal, from a point of cleanliness and light, and the advantage to textile manufactures and printers, for example, in the entire absence of "frictional electricity," due to the absence of belting! The progress toward this ideal is interesting to note.

In the fall of 1888, the writer laid out and supervised the installation of the first complete shop plant in which no belts were employed between the engine room and the work rooms. In this instance an 80-horse-power engine was employed to drive a 50-kilo-watt dynamo. From the switchboard six separate power circuits were taken off, one to each of the floors in the building, each of the circuits being provided with an ampère meter, a fuse cut out, and a suitable double-pole switch, all lighting being provided for on separate circuits. This arrangement of distributing circuits allowed not only complete control of the entire distribution of power in the engine room, but also gave to the engineer in charge a con-

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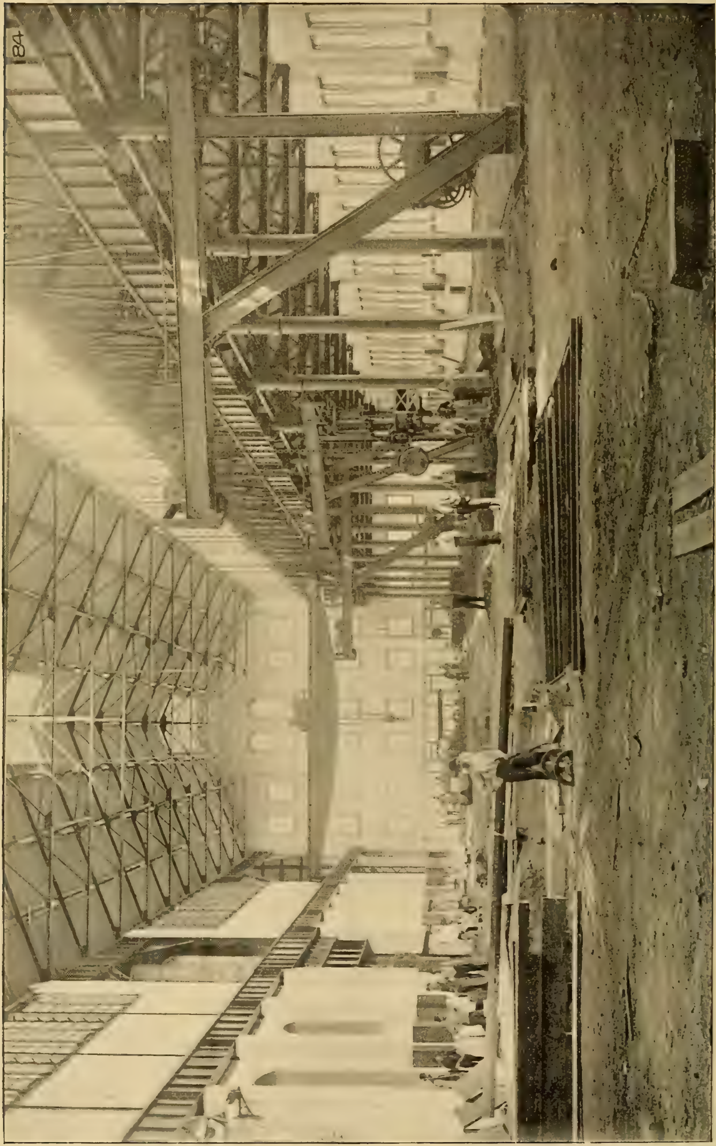
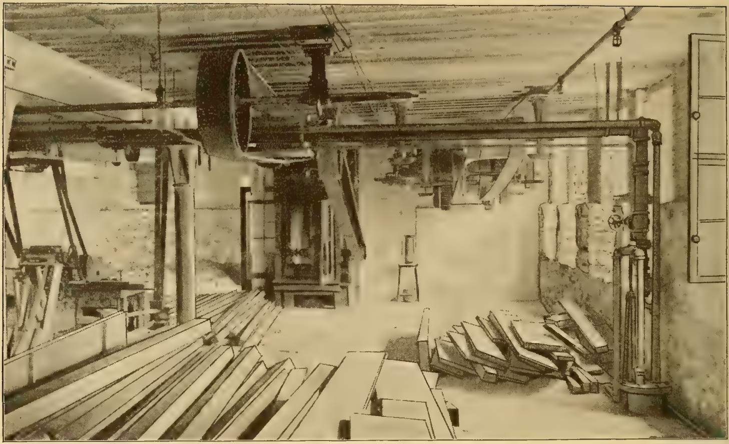


A YALE & TOWNE ELECTRIC JIB CRANE AND A MORGAN ELECTRIC TRAVELING CRANE IN THE FOUNDRY OF FRASER & CHALMERS, CHICAGO, ILL.

DOUBLE TROLLEY ELECTRIC TRAVELING CRANE SHOWN AT THE CHICAGO EXPOSITION, BY THE MORGAN ENGINEERING CO., ALLIANCE, OHIO. 83-FOOT SPAN. SEVEN ELECTRIC MOTORS.

stant indication of the power used in each department, by means of the ampère indicators. The motor distribution in this case was by means of one or two motors on each floor. This plant has operated successfully and economically for the past five years, the coal consumption for light, heat and power, for from 150 to 200 machinists, being about 300 tons of coal per year.

In the spring of 1889, the Hickok Manufacturing Company of Harrisburg, Pa., commenced negotiations with the Harrisburg Electric Light Company for power to run their large factories. The successful termination of these negotiations led to the purchase by the Hickok Manufacturing Company of three 20-horse-power and two 15 horse-power electric motors for the operation of their different departments, some of which are illustrated in these pages. The writer wishes that he were at liberty to give the exact figures as to



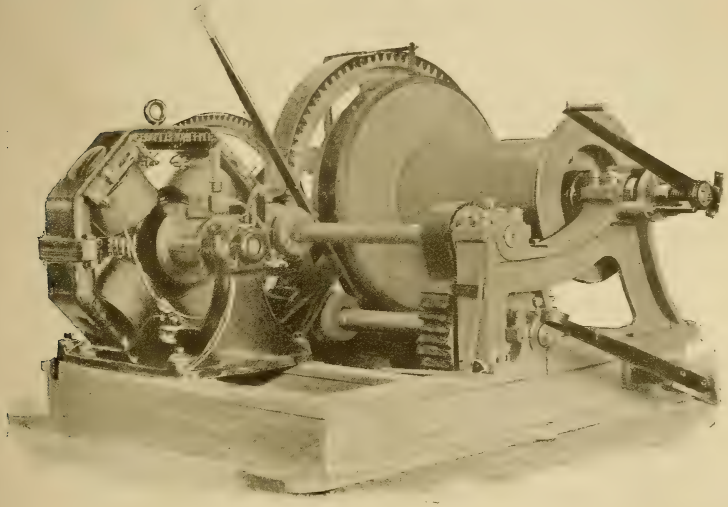
ELECTRICALLY EQUIPPED WOOD-WORKING DEPARTMENT OF THE HICKOK MFG. CO., AT HARRISBURG, PA.

cost of power to operate this factory. He has, however, the permission of Mr. L. S. Bigelow, the general manager of the Hickok Company, to quote his statements as follows :

"Regarding the use of electric motors in and about our plant, I would say, that for running section A of our wood-working department, where the rough lumber is ripped, sawed and surfaced, we have installed a 20-horse motor. This same motor is connected with our 5-ton elevator. This elevator has a platform, 10 x 15½ feet. Among other things which we have raised upon it, was one of the fire engines belonging to our city fire department. It was sent to our shops for repairs. The weather being inclement, the pole of the steamer was taken off and the machine proper was wheeled upon the platform of the elevator. It was then raised to one of our floors given to repair work. The motor showed no sign of overloading or of a tendency to give in any way, although we were using the power for other purposes at the same time that the hoisting was being done. Another 20-horse-power motor is installed upon the north side of our machine department floor, and the third on the south side. Each of these last two motors is belted to its own line shafting, so that half of the room may be operated independently of the other half. In this room we are using all the tools known to a well equipped machine shop—planers, lathes, drills, gear cutters, shapers, milling machines, etc.

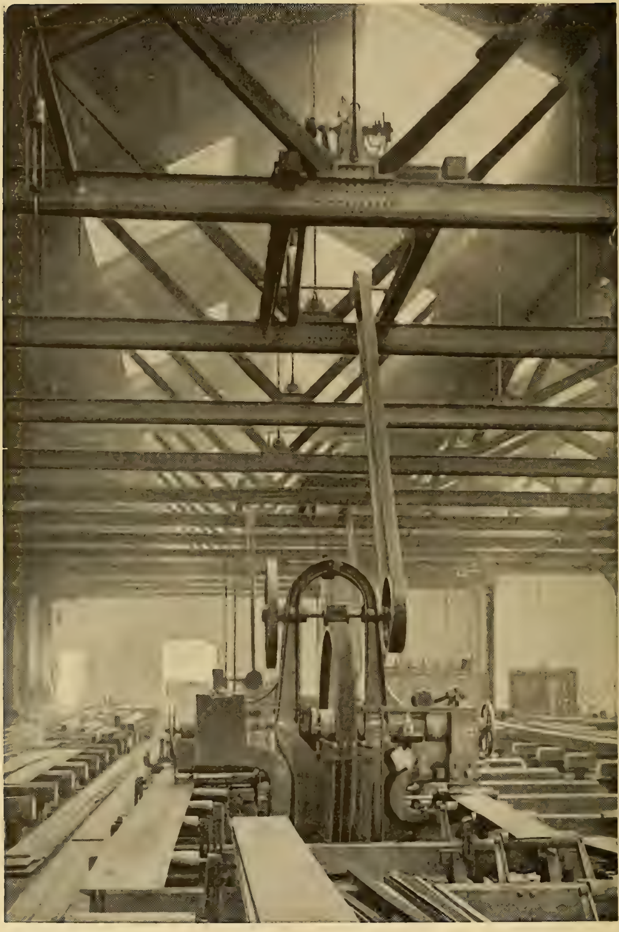
"A 15-horse-power motor is used in our wood-finishing department, and a third and a fourth motor are used in our testing department, they being placed upon movable platforms and arranged with speed reducing wheels, so that any desired speed may be attained at will, and the motors be moved to any point desired. Our expenses for repairs during the last four years include a new starting box and a few brushes. That, we believe, is all, excepting, possibly, some fuse plugs, which have been burned out from time to time. * * * It is our hope that we may find it possible in the near future to attach individual motors to various machines in our shops, thus doing away with as much countershafting and main line shafting as possible."

Following the Hickok Manufacturing Company, the Globe Tobacco Company, of Detroit, contracted for electrical distribution of power in new factory buildings into which they were about to move. This plant was started in May, 1889, since which date all "Globe Tobacco" may be said to possess, truly, an electrical flavor. The Globe dynamo plant consists of one 40-kilowatt, 220-volt dynamo. An extract from a recent letter from Mr. W. R. Hamper, secretary and treasurer of this company, reads: "The daily average record is 80 ampères for the machinery part (17.6 kilo-watts), and when we run the lights, of which we have 250 all over the buildings, the ampère record runs up to 100 (22 kilo-watts). Of motors, we have one 15-horse-power, two 10-horse-power, three 5-horse-power, one 3-horse-power, one 2-horse-power, and two 1-horse-power, distributed as follows: The 15-horse-power is running our plug factory across the alley. The two 10-horse-power motors are running two flake-cutting machines and dryers and also one long-cut cutting machine. The above two 10-horse-power motors are running in connection on the same shaft. Of the three 5-horse-power motors, one is running the machinery in the blower rooms, one is running a furnace dryer and machinery in the sieve room, and the other is running our moistener fan. The three horse-power motor is running the blower fan. The 2-horse-power motor is running our printing room, with four presses and one paper cutting machine. One of the two 1-horse-power motors is running the casing roller machine, and the other is running our granulated smoking packing machine. We find our electrical plant of great convenience, both for running our machinery and furnishing light for our factories; also in running any part of our machinery independently; for when we wish to stop any one machine, we stop the motor which runs the machine; consequently our buildings are not full of idle running shafting."

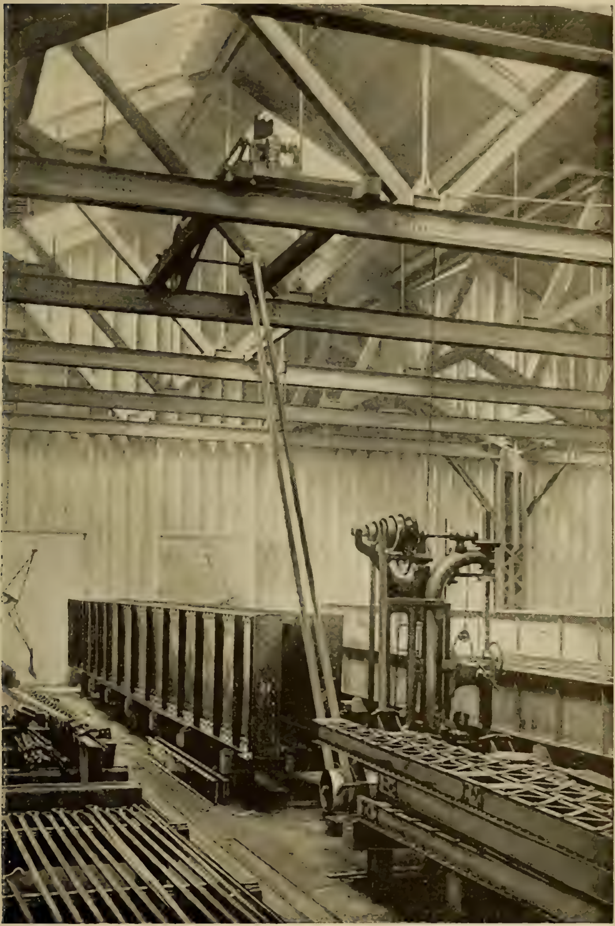


AN ELECTRIC "SKULL CRACKER" FOR BREAKING UP SCRAP IRON.

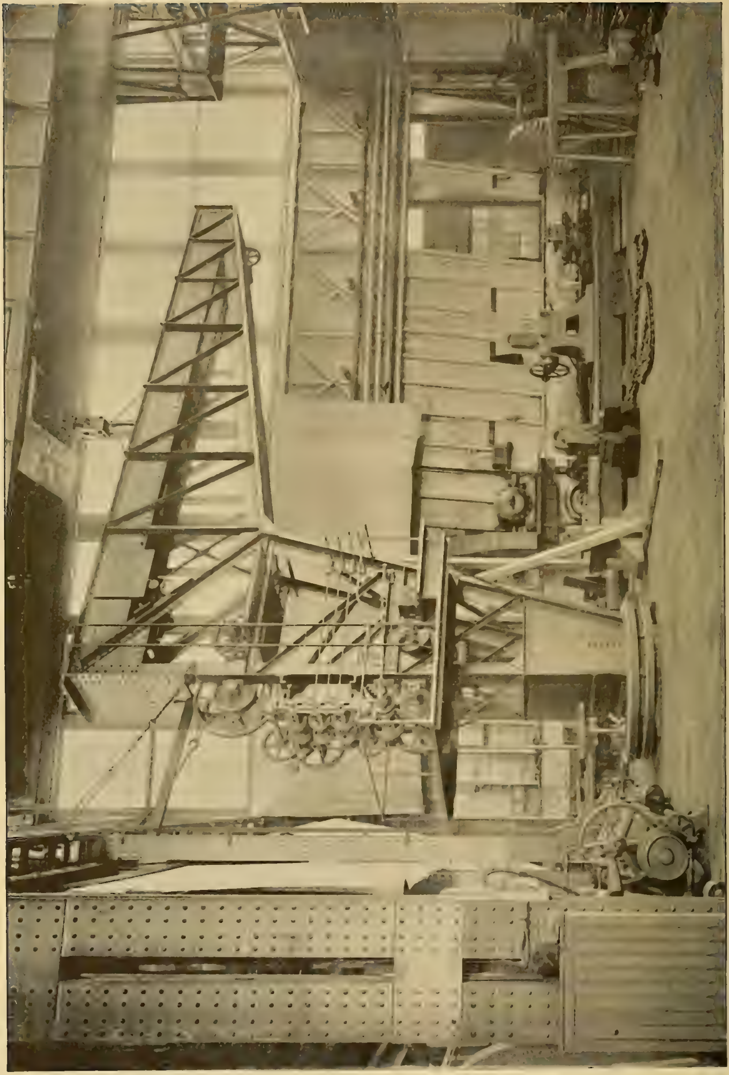
Following the Globe Tobacco Company with electric power plants for distributing either the whole or part of their power, came the American Encaustic Tiling Company, of Zanesville,



COMBINED PUNCH AND SHEAR, DRIVEN BY AN 8½ H. P. GENERAL ELECTRIC MOTOR, AT THE WORKS OF THE WROUGHT IRON BRIDGE CO., CANTON, OHIO.

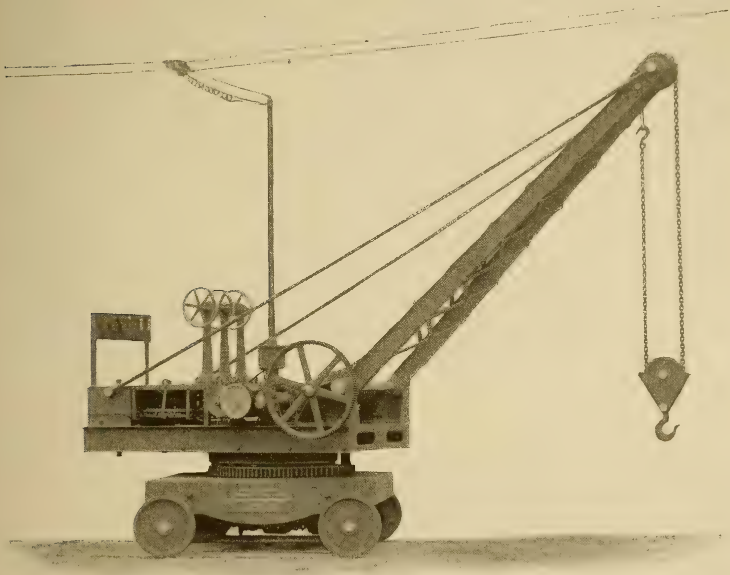


A THREE-HORSE-POWER MOTOR DRIVING A LARGE DRILL AT THE WORKS OF THE WROUGHT IRON BRIDGE CO.



ELECTRIC JIB CRANE, BUILT FOR THE CAMBRIA IRON CO., AT JOHNSTOWN, PA., BY WM. SELLERS & CO., OF PHILADELPHIA, PA.

Ohio; the Grant Locomotive Works, at Chicago; Messrs. Fraser & Chalmers, of Chicago; the Bucyrus Steam Shovel and Dredge Company, of South Milwaukee; the Pabst Brewing Company, of Milwaukee; the Walter A. Wood Harvester Company, of St. Paul; the Carnegie Steel Company, of Braddock, Pa.; the Cambria Iron Company, of Johnstown, Pa.; the Pencoyd Iron Works, of Pencoyd, Pa.; the Eastman Company, of Rochester, N. Y., and The Page Belting Company, of Concord, N. H. Many other mills and factories have adopted the transmission of power electrically, either as a whole or part of their power system. The high character and engineering ability of the numerous establishments which have adopted the electrical transmission of power will commend themselves at once to the reader, as determining the reliability of electrical apparatus of standard makes, applied after well-thought-out methods.



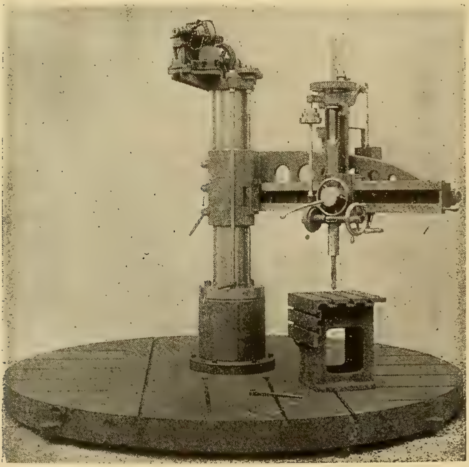
LOCOMOTIVE CRANE, BUILT BY THE MORGAN ENGINEERING CO., ALLIANCE, OHIO.

Setting aside, as answered, the question of reliability, let us take up the question of economy in operation, convenience and flexibility. The apparent losses in shafting had always been vaguely estimated until the advent of the electric motor, by which, with the aid of an ampère indicator, these losses are readily and accurately determined. As a result of a test in some thirty shops of varied descriptions, made in 1890, which tests were embodied in a paper read by the writer before the National Electric Light Association at their annual meeting in August, 1890, it was discovered that 68 per cent. of the average power applied in these shops was consumed in the shafting. Some data recently very kindly furnished to the writer by one of the large electric companies, which, by the way,

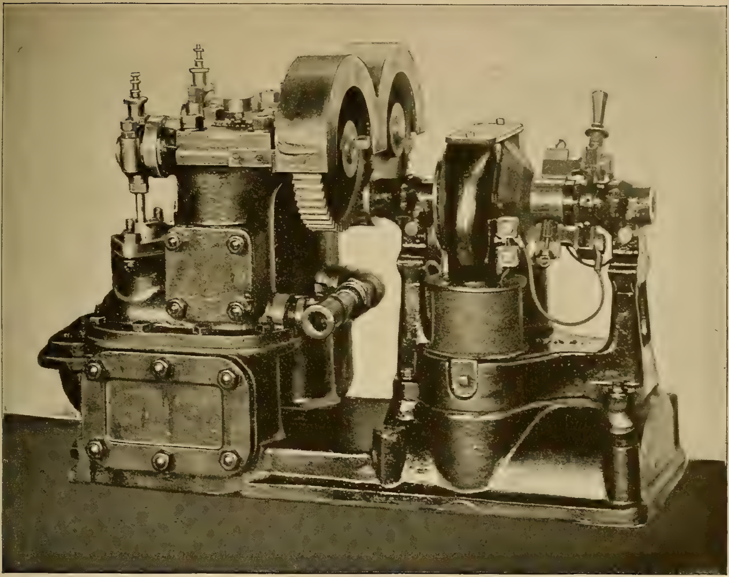
AN ELECTRIC DERRICK HOIST.

is furnishing current for operating about four or five thousand horse-power in electric motors, cover seventy-one shops. The totals of these shops showed that 121,524 watts represented the average total energy supplied, and that 84,700 watts were consumed in the shafting, etc., being 69⅔ per cent. of the average power, thus approximately checking the tests of 1890. These friction losses in shafting in the mills and factories before referred to have been partially eliminated by means of grouping tools in sets and otherwise, driven by electric motors, so that entire sets might be completely shut down when not actually in use without interfering with the remainder of the shops, and long lines of transmitting shafting and belting between floors or from building to building have thus been dispensed with.

An interesting example of the economy derived from this grouping of tools is found in a factory now being equipped with an electrical transmission system. A preliminary experiment in this factory showed that the saving in fuel alone will probably exceed 50 per cent. and possibly 60 per cent. In one recent instance a card, indicating 59 horse-power, was taken from an engine driving a large machine shop, a blacksmith shop with pneumatic hammer, blowers, etc., a pattern shop, and numerous special tools on three floors of a building about 75 feet



A RADIAL DRILL WITH A DIRECT-CONNECTED CROCKER-WHEELER MOTOR.

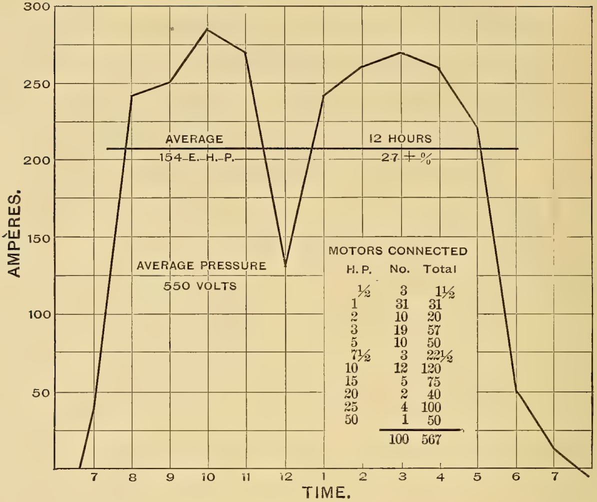


A PUMP FOR HOUSE TANK SERVICE, DRIVEN BY A CROCKER-WHEELER MOTOR.

square. This card was taken with all tools idle, thus showing friction only. The same tools were rearranged and grouped into several sets, driven by electric motors, and under these conditions the average indicator card from the engine driving the dynamos which furnish the power for these same tools is about 25 horse-power, covering friction, power for the tools and all.

The convenience and flexibility of an electrical power transmission system are frequently commented on by present users, from the fact that single tools or small groups of tools may be efficiently operated in isolated locations, or locations at considerable distances from the main power plant. Notable instances of this kind are found in the plant of the Bucyrus Steam Shovel and Dredge Company, where they are operating an automatic electric pump, some 2500 feet from their power plant, for their water supply. The Cambria Iron Company also are operating a pump for draining one of their mines, this pump being about 6000 feet from their power plant.

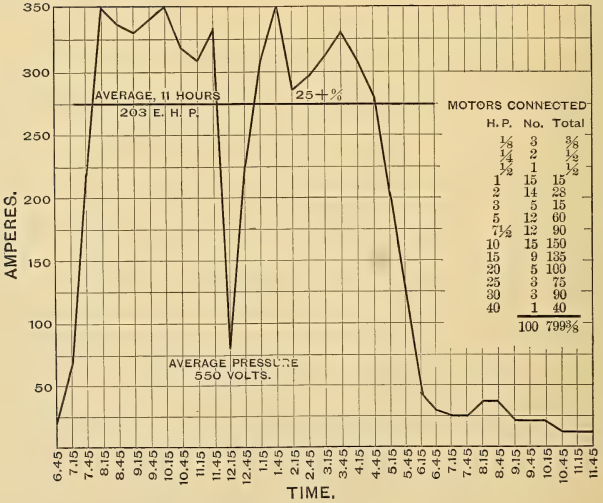
The writer is indebted to Messrs. Stone & Webster, of Boston, for some very interesting data with reference to the electrical transmission at the Cumberland Mills, Saccarappa, Me., the mills being situated about 6000 feet from the Saccarappa Falls. At the falls are located five 80-horse-power dynamos, driven by three 48-inch turbine wheels. Only four of the dynamos are regularly operated, the fifth being held as a reserve. The power is carried to the mills by a suitable pole line, and there operates from eight to ten electric motors in the different departments of the establishment. This plant was installed in 1891, and works both night and day. The value of a horse-power of steam under the conditions of operation at the Cumberland mills would not be less than from $100 to $125 per year, while the cost per horse-power



MOTORS CONNECTED

H. P.	No.	Total
½	3	1½
1	31	31
2	10	20
3	19	57
5	10	50
7½	3	22½
10	12	120
15	5	75
20	2	40
25	4	100
50	1	50
	100	567

DIAGRAM NO. 1.

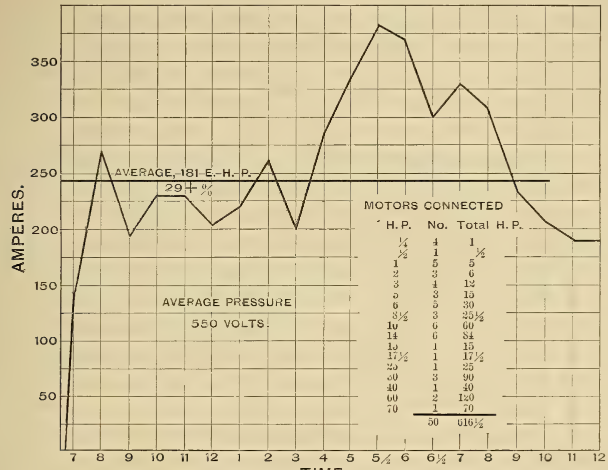


MOTORS CONNECTED

H. P.	No.	Total
⅛	3	⅜
¼	2	½
½	1	½
1	15	15
2	14	28
3	5	15
5	12	60
7½	12	90
10	15	150
15	9	135
20	5	100
25	3	75
30	3	90
40	1	40
	100	799⅜

DIAGRAM NO. 2.

per year of each horse-power delivered from the motor pulleys, allowing for all losses of conversion and transmission, is only about $35, this cost covering all running expenses, repairs, depreciation of plant, and interest on the entire cost of the equipment. That these vast economies, made possible by well-designed electrical transmissions, are appreciated by large manufacturers, is shown by the great number of plants under contemplation at this time of general commercial depression.

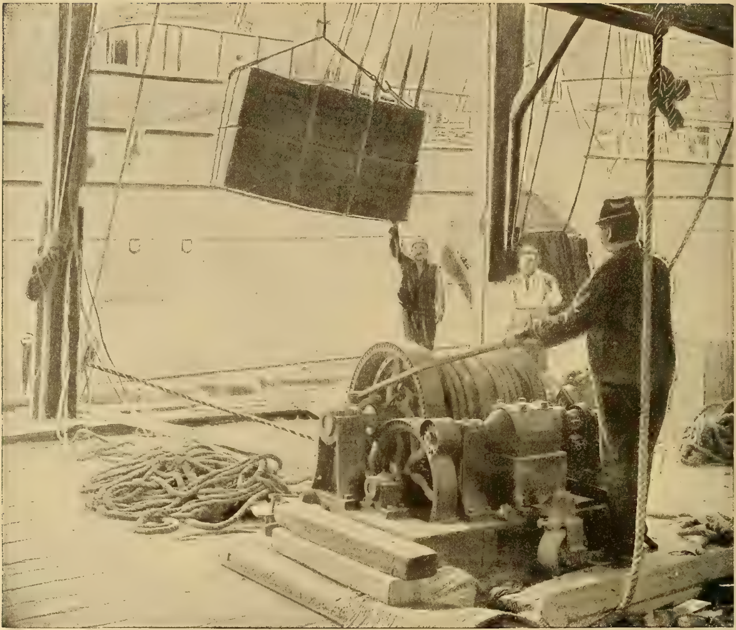


MOTORS CONNECTED

H. P.	No.	Total H. P.
¼	4	1
½	1	½
1	5	5
2	3	6
3	4	12
5	3	15
6	5	30
8½	3	25½
10	6	60
14	6	84
15	1	15
17½	1	17½
25	1	25
30	3	90
40	1	40
60	2	120
70	1	70
	50	616½

DIAGRAM NO. 3.

In a well designed plant, the operation of the entire equipment is practically under the eye of the engineer through the medium of the switchboard indicators, and the exact power supplied to any one or all departments is readily and continuously determined if desired. Another very interesting, as well as economical, feature can best be illustrated by the diagrams on this and the opposite pages, which, with a few supplemental words, will explain themselves. They represent the outputs of three different electric power stations, one in an Eastern, one in a Central, and one in a far Western State, obtained by the writer through the courtesy of the station managers. The circuits from these stations are exclusively motor circuits, although on the circuits covered by diagram No. 3 quite a number of motors are used to drive dynamos for operating electric lights. This feature accounts for the rise and fullness of the curve in the diagram at and after three o'clock. On the circuits covered by the diagram No. 2 some of the motors are five miles and more distant from the power station. The deductions made by a study of these curves seem to indicate that in an electrical distribution system employing a considerable number of motors, the initial dynamo plant need be but from 25 per cent. to 40 per cent. of the rated capacity of the motors connected. In order to check off this phenomenal condition, actual meter readings were taken monthly from fifty-three different shops covering a period of from four to six months, current being sold to these shops on the meter basis. The results showed that only 25½ per cent. of the nominal capacity of the motors was employed, thus practically checking the

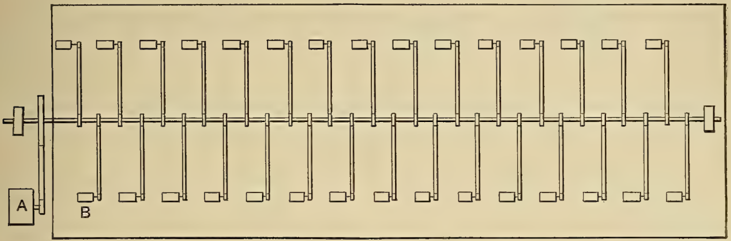


AN ELECTRIC DOCK HOIST, EQUIPPED BY THE GENERAL ELECTRIC CO.

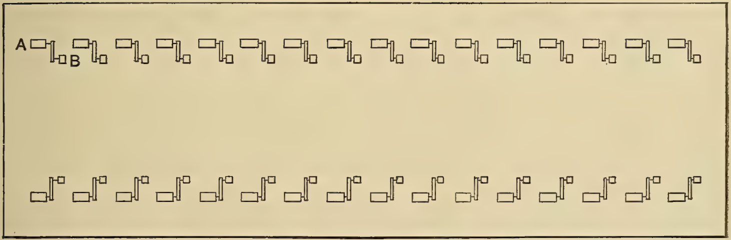
conditions indicated by the diagrams of the central power plants.

This great saving derived in an electrical system, owing to the intermittent use of tools, was long since taken advantage of by the builders of traveling cranes, and to-day probably ninety-nine out of every hundred traveling cranes installed are operated entirely by electric power, an independent motor being used for each of the several functions of the crane. Many foundries now work their jib cranes with directly geared motors, taking current, in many instances, from the same dynamo which lights the shops. An electric "skull-cracker" has recently been installed for some iron furnaces near Pittsburgh for breaking up scrap iron, this device being operated from dynamos only intermittently used for operating traveling cranes. Many of the large iron works are building electric motors directly into both "hot" and "cold" saws, punching and shearing machines, roll tables, etc. Thus is the ideal being slowly but surely developed.

The general advantages of distributing power electrically on the "grouping system" having been explained, there remains to be shown the further advantage of the ideal or direct connected system. In a paper read before the National Electric Light Association at their meeting at New York in 1887, the writer, after referring to various applications of motors, and the approximate average actual use of the motor as related to its rated capacity, said: "The next application of importance on the list is the driving of sewing machines. In the tests which I have been able to make on this class of work, I have obtained some singular results. To illustrate, I will give you a record of two cases which are about the average. Case No. 1 is a shop in which are thirty sewing machines, connected to a two-horse-power motor. At the time that these tests were made, there were but twenty operators at work, leaving ten idle machines; the entire shafting, however, being in operation. The class of goods manufactured in this shop is a cheap grade of cotton and wool pants, rather heavy goods to sew. A voltmeter across the terminals of the motor gave the following readings with the current at nine ampères: Minimum, 90 volts; maximum, 148 volts; average, 119 volts, or a general average of, say, 4 volts per machine.

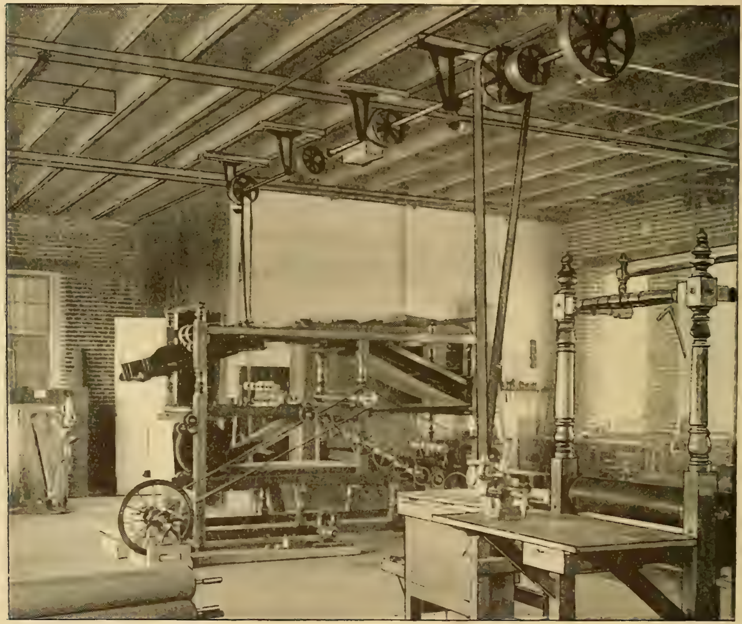


CASE NO. 1—THIRTY SEWING MACHINES; TWENTY OPERATORS. AVERAGE POWER, 1071 WATTS, OR 1.43 EL. H. P. *A* REPRESENTS THE MOTOR; *B*, ONE OF THE SEWING MACHINES.



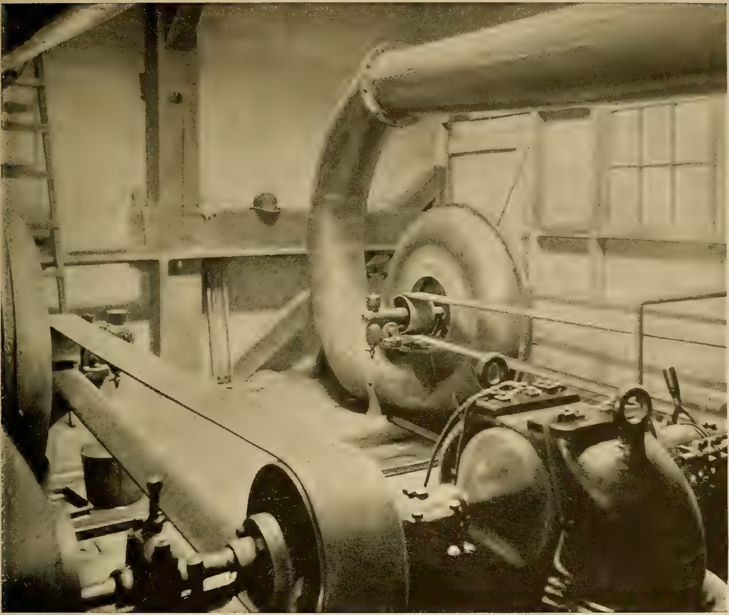
CASE NO. 2—THIRTY-TWO SEWING MACHINES; TWENTY-FOUR OPERATORS. AVERAGE POWER, 702 WATTS, OR 0.94 EL. H. P.

"Case No. 2 is a shop in which are thirty-two machines, running at about 1200 stitches per minute, each being supplied with an individual motor of ⅛ horse-power rated capacity, the class of goods manufactured being men's summer clothing, such as white duck vests, flannel coats and vests, etc., the duck from which these vests are made being about as hard work on a sewing machine as can be found. In this shop twenty-four operators were at work. The maximum volts in this case were 116, and the minimum 40, giving a general average of but 78 volts, or about 2½ volts per machine, with four more operators than in the first case, in which we had a general average of 119 volts. This shop, No. 2, has been paying the local electric light company $32 per month for more than a year, which is the same price that the company charge for current for a 4 horse-power motor, approximating to 400 volts, which the company contracts to deliver. On a contract for three years, the electric light company would be money in pocket if they would present the customer in case No. 1 with thirty small motors. * * * This is but one page from the thus far unwritten history of the much-maligned small motor. * * * A more striking illustration of the advantages to the electric light company in the subdivision of power into the smallest possible units it would be hard to find. There is a difference in efficiency of from 15 to 20 per cent. in these two sizes of motors, but this difference is fully lost to the large motor in driving the shafting, and the small motor still has the advantage of being out of circuit entirely when the machine which it is driving is stopped. There is scarcely a manufacturing industry which does not possess its busy and dull seasons. This means that in no industry will over 75 per cent. of the machines or machinery employed be in average operation. The entire shafting in the shops must be kept in operation the entire year, often for less than 50 per cent. of the machinery. Subdivide these same shops into as many small units as possible, and the current necessary to operate the shafting for this idle machinery will be saved, besides the saving from frequent stops while the machinery is in active use.''



PORTABLE ELECTRIC MOTOR AT THE HICKOK MFG. CO.'S WORKS, AT HARRISBURG, PA.

The writer believes that he states it correctly when he asserts the fact that these were the first authentic data ever published relating to the comparative commercial efficiency and economy of a shop operated electrically as a unit, and one in which the power was divided into the greatest possible number of small units, thus doing away with shafting entirely. It would be hard to find a case that could show the comparative economy of the individual or direct connected motor to less advantage. In



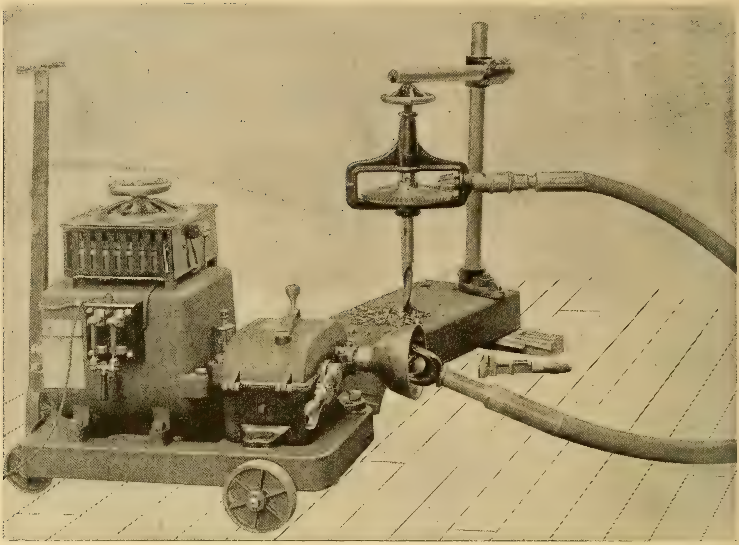
AN ELECTRIC BLOWER OUTFIT AT THE WORKS OF THE EBERHARD MFG. CO., AT CLEVELAND, OHIO.

case No. 1 there was a single, well-constructed line shaft, supported in self-adjusting and self-oiling pillow blocks, with the motor bolted directly to this line shaft, thus giving the least possible friction obtainable in a shafting transmission. Making allowance for the four extra operators at work in case No. 2, the power consumed is shown to be but little more than one-half of that consumed in case No. 1.

Taking advantage of this known condition of economy in operation, the Crocker-Wheeler Electric Company, of Ampère, N. J., have equipped many of their tools with direct-connected motors.

One of the buildings occupied by this company is about 400x70 feet, and another about 400x60 feet. On a recent inspection of the engine room at this factory, it was found that but 11 kilo-watts were being delivered to the entire shop, or from about 20 to 22 horse-power indicated in the engine. It is undoubtedly a fact that, for the tools employed and the area covered, at least from 50 to 100 horse-power would be required for the shafting and countershafting alone, had the power been transmitted after the usual shafting practice. Some very complete articles on the equipment of this shop, written by Dr. Wheeler, appeared in The Electrical Engineer of April 12 and October 4, 1893.

A final and very interesting application of an electric motor is the operation of a pump. A steam pump requires from about 60 to 80 pounds of water evaporated into steam per hour per horse power of water duty. Allowing 20 pounds of water per horse-power per hour for a steam engine driving a dynamo (and many engines are running on 16 or 18 pounds of water), a horse-



AN ELECTRIC MOTOR DRIVING A STOW FLEXIBLE SHAFT.

power of water duty can be delivered from an electric pump, with say, 30 to 40 pounds of water evaporated. This difference in favor of the electric pump increases materially as the distance from the boiler plant is increased. Numerous other illustrations of peculiar efficiencies derived from special applications of electric power might be cited; many illustrations also might be given of ill-advised applications. Suffice it to say, that the best results in an electrical transmission of power are obtained only by a very careful analysis of the propositions involved in each case, and by a comprehensive and intelligent system of distribution which will suit each individual requirement.

* * *

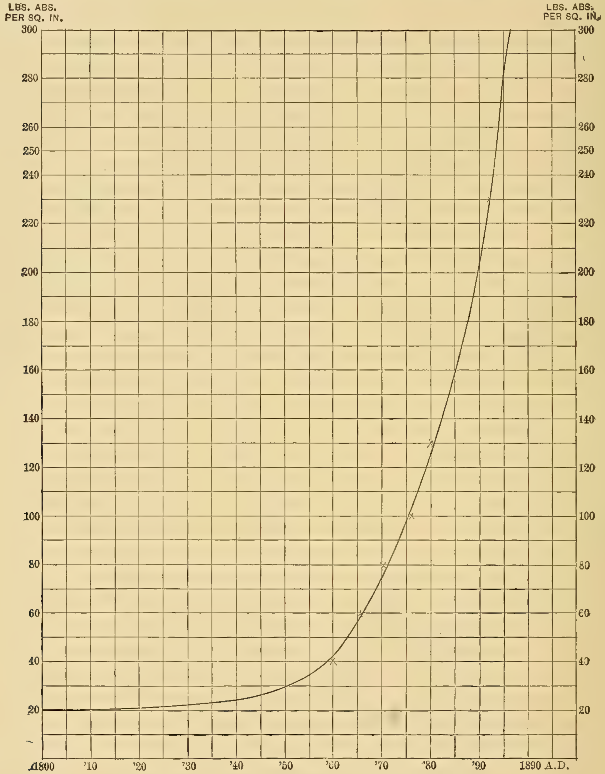
PRESENT AND PROSPECTIVE STEAM ENGINE ECONOMY.

By Professor John H. Barr, M. Am. Soc. M. E.

THE birth of the modern steam engine was nearly contemporaneous with the birth of our Republic, and the Centennial Exposition of 1876 fittingly marked the rounding out of the first century in the history of man's greatest political institution and of man's greatest mechanical achievement. The beginning of the second century of the steam engine ushered in a new era in its development, and the interval of time between the Centennial Exposition and the recent Columbian Exposition embraces almost the entire development of the modern compound engine as applied in land service, and of the modern high-speed steam engine.

As we approach the completion of the fruitful first quarter of the second century of the steam engine, we are naturally led to scan its record and to indulge in a review of its lessons, with the hope that some light may be thrown ahead. This period has seen wonderful changes in engineering practice. Not only have new demands, notably those incident to a remarkable electrical development, imposed trying conditions, which have been admirably met, but the improvement in the economy of fuel in the older lines of service has been even more noteworthy. The first century may be said to cover the era of mechanical improvement, at least as to the slow speed types of engines. Designs have been somewhat improved, and construction has been generally refined since then ; but the simple engines of the older types were substantially as perfect twenty-five years ago as they are to-day. The enormous demand for steam power had called into existence a large number of steam engine works, and the resulting competition had forced builders to avail themselves of the high-grade construction which the development of the mechanic arts made possible. Steam pressures had gradually advanced from atmospheric, in the early days of Watt, to about 100 pounds per square inch at the time under consideration, and the ratio of expansion had increased as well, though the practical limit of economical expansion in a single cylinder had checked, somewhat earlier, further advancement along this line.

The past twenty-five years have witnessed wonderful improvement in the materials used in boilers, in the methods employed in their construction, and also a great development of certain types of boilers now in extensive use. All of these elements have contributed to the attainment of higher pressures and better economy has made, and will continue to make, such pressures desirable on the score of efficiency. During the first century steam pressures had increased continuously, and efficiency had correspondingly improved. High ratios of expansion, without which the greater pressures could not be employed to full advantage, had already been checked by the obstacle of "cylinder condensation and re-evaporation." A crisis was at hand and much further advance along the old lines seemed improbable. At this juncture, the old expedient of compounding was revived, and owing to this revival, progress was no longer blocked. The multiple-cylinder engine has cooperated with improved methods and materials of boiler construction in securing the realization of the higher pressures of to-day, and the latest and greatest of the great achievements of Mr. Reynolds—his marvelous Milwaukee pumping engine—has recently afforded a demonstration of the extent to which the losses of a steam engine can be reduced by skillful treatment. We shall have occasion, later, to refer more in detail to the performance of this "record breaker."



PROGRESS IN STEAM PRESSURES FROM 1800 TO 1900.

In commencing the survey of a new and extensive country, it is desirable to first establish a base-line from which to triangulate. Before investigating the wastes, avoidable and otherwise, of the engine as we now know it, and in advance of any attempt to predict the probable gain from higher pressures, it will be well to briefly consider the probability of such pressures becoming practically attainable. This suggests the questions: Are steam pressures steadily increasing? Can we expect to carry much higher pressures in practice than are now employed? Are such pressures desirable as contributions toward better final commercial efficiency in the utilization of steam? So far as we can depend upon history in drawing deductions, the reply to the first of these queries is unquestionably in the affirmative. It may be again stated that pressures have risen steadily since the extensive use of steam began, and that we may expect a gradual continuation of progress along this line for an indefinite time, though perhaps at a decreasing rate. Mr. Thomas Hall, a graduate student of Sibley College, Cornell University, recently made a review of the history of steam pressures at the suggestion of Professor Thurston, and the diagram on the opposite page* is a graphic representation of the results of his examination. It will be noticed that the pressure in use in 1890 is given as about 200 pounds per square inch. and that the rate of advance, far from showing indications of approach to a limit, is itself increasing apparently. The period covered, which includes our entire experience with the steam engine, is so long, and the curve showing the complete history is so regular, that we can hardly entertain a doubt as to the continuation of the progress at least for some time to come. Of course this is not a conclusive proof that the rise in pressure is to go on indefinitely or even for any considerable period, but it is strong presumptive evidence that this may be the case in the immediate future at least.

The second query: "Can pressures greatly exceeding the highest pressures now used in practice be expected?" is mainly a question of safety, and leads to a consideration of the present materials, methods of construction, and types of boilers, and of the probability of their decided improvement in the near future. The remarkable advances in steel making have already given us extremely reliable materials, and metallurgists are only beginning to understand the possibilities of the wonderful alloys of iron, carbon and other elements. Nickel, manganese, chromium, tungsten and other metals, alloyed with iron and skillfully manipulated, have recently given marvelous products for armor plates, projectiles, and other special requirements. While, as yet, the older alloy of carbon and steel has maintained its supremacy as a boiler material, it would be rash, in the light of recent experience, to predict that its superior can never be produced. There is much promise that welded seams, already applied commercially, and apparently with considerable success, may add from 15 to 25 per cent. to the effective strength of the material, when made up into a boiler, by elimination of the weakness of the riveted joint.

New types of boiler may also contribute to the rise of steam pressures. The water tube, and other sectional boilers, long since adopted extensively on account of their admitted safety, have recently greatly gained in favor, as is attested by the large number of modifications now on the market. A striking feature of the late Columbian Exposition was the large boiler plant of 20,000 horse-power capacity, made up entirely of water tube or sectional boilers. But all sectional boilers have, so far, used comparatively large steam drums, which seem to be indispensable adjuncts. It is, therefore, not to be expected that the type can entirely eliminate the requirement of superior materials for high pressure boilers. It is to be remembered, however, in connection with this, that the highest regular pressures are carried in boilers of large diameter. The difficulties of adapting externally fired boilers to the conditions of marine practice have practically restricted the choice in ocean service to the shell type of steam generator, and there high pressures have been required for economy. The fact that these pressures have been carried in such large boilers is, in itself, the best evidence that pressures can be elevated, even at the present day, much beyond those now commonly employed, for the steam drum in the so-called "safety boilers" can, in the light of successful experience with the large shells used in the marine service, hardly be said to have placed a limit to pressures, even with our present materials. The new Cunard vessels carry steam of 165 pounds pressure per quare inch in boilers of 216 inches diameter, and by decreasing diameters, the pressures could be correspondingly increased with safety. As additional evidence of the possibility of safely carrying much higher pressures than those with which we are now familiar, the Boston scheme of several years ago for transmitting energy through the medium of highly superheated water, may be recalled. The Heine boilers built for this service carried a pressure of 450 pounds without evidence of unusual distress or deterioration. Experiments now being planned at Sibley College, Cornell University, contemplate the use of steam at 500 pounds pressure per square inch, and prominent and responsible boiler makers have expressed their readiness to meet this demand. Perkins and Albans employed much higher pressures than this experimentally, and without serious difficulty, forty or fifty years ago. It does not seem safe to assert that it is even now impossible to carry in practical operations a pressure of 500 pounds per square inch, at least so far as safety fixes the limit.

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*This diagram is taken by permission from a paper "On the Maximum Contemporary Economy of the High Speed Multiple Expansion Steam Engine," read by Dr. R. H. Thurston at a recent meeting of the American Society of Mechanical Engineers. The writer acknowledges obligations for many suggestions on the treatment of his subject to this able paper of Professor Thurston.

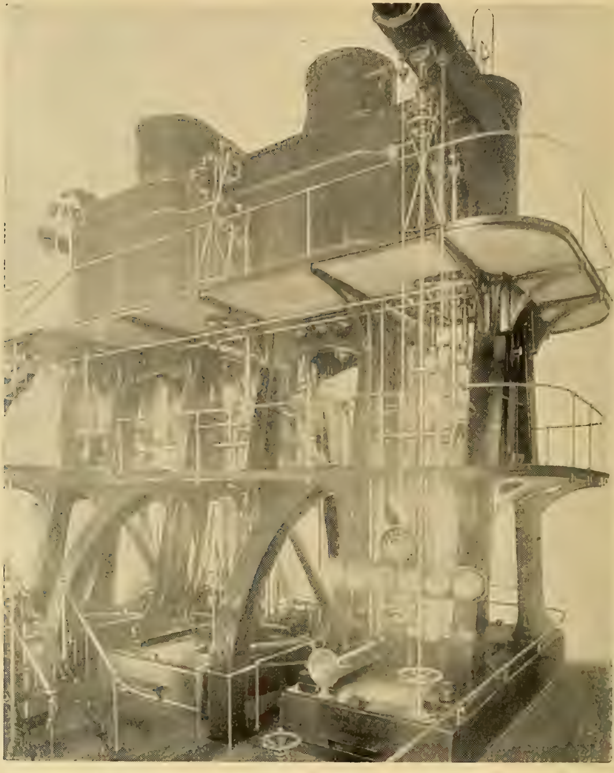
If the preceding reasoning be reliable, it appears that there is no immediate prospect of the rise in steam pressure being checked by the limitations imposed by considerations of safety. This brings us to the third question, "Will steam considerably above the higher pressures of contemporary practice be conducive to better economy?" It may be repeated that increase of steam pressure calls for increase in the ratio of expansion, and this brings with it serious inherent losses through cylinder condensation and re-evaporation, if expansion be carried on in a single cylinder. If the expansion be subdivided among several cylinders, this waste may be reduced so that the steam required by an actual engine, compared with the amount that would be demanded in the absence of this loss, need not of necessity increase with the greater total ratio of expansion. The case is different with the other obstacles to high pressures and ratios of expansion, such as difficulties of efficient cylinder lubrication, due to higher temperatures; increased internal friction of engine, due to its larger size for a given capacity; greater radiation loss, due to the higher initial temperature and larger surfaces exposed, etc.

The modern steam engine is a symbol of perfection to the layman, especially if it has a large fly-wheel, or is run at a high rotative speed and liberally adorned with nickel plate; but to the initiated it is otherwise, and the not altogether disinterested builder contents himself with a claim of relative superiority. It is more satisfactory to him to compare the performance of his engine with that of one constructed by a less successful competitor, than with the energy expended in the boiler furnace. A comparison with other engines is proper and valuable. From a commercial standpoint, it is more important to know how a given engine ranks as compared with other engines actually upon the market, than to know its standing relative to an ideal standard which may never be attained in practice. Engines are usually made to be sold, and, as a general thing, the man who buys the engine has a mind so constituted and trained that it comprehends the conception of a dollar with greater readiness than it grasps the idea of a thermal unit. We are concerned, in the present instance, however, not so much with the best engine of to-day as with the best possible engine of the future, and as our discussion must be of a speculative nature, we should approach the problem with the physical, rather than the commercial, yardstick. For this purpose a pound of coal is a better measure than an ounce of gold. These of course have a definite relation, but the former, a unit of heat, is fundamental, and hence is more appropriate.

It will be well at the outset to enumerate the principal sources of waste in the prevailing form of the steam engine, and these may be treated under two heads. First, wastes which may be reduced, but cannot be totally eliminated; second, those which we can conceive as being possibly entirely overcome. The science of thermodynamics proves that, of necessity, a large loss of the energy stored in our fuel is involved in the operation of any heat engine, working between finite limits of temperature. If the cycle in which the engine works is not defective, this loss can be reduced only by either of two possible methods, increase of the initial or reduction of the final temperature. This inevitable thermodynamic loss will probably always remain the primary loss in the steam engine and its magnitude in the higher practice of to-day may be indicated by a few simple calculations.

Assume the conditions that the initial pressure is 136, and the condenser pressure, 1.25 pounds per square inch. These figures correspond very nearly with the average values of the Sibley College trial of the Milwaukee engine. The temperatures corresponding to these pressures are about 350° F, and 110° F., or 812° and 572° absolute, respectively. If a heat-engine operate in the most efficient manner possible, namely, in what is designated the Carnot cycle, its efficiency is equal to the difference between the absolute initial and final temperatures, divided by the absolute initial temperature. With the limits of temperature given above, the efficiency of a Carnot cycle would be about 29.5 per cent.; 70.5 per cent. of the energy of the steam entering the engine would be lost. The efficiency of the fuel would be still less, as the boiler losses have not been included in the foregoing computation. It is to be noted, furthermore, that no method has yet been devised for operating a steam engine in the cycle of maximum economy. In the Carnot cycle the heat expended, for each pound of steam used, equals the latent heat of vaporization at the initial pressure and temperature; that is, steam is formed from water at the temperature of the initial steam pressure. In the actual engine, the steam must be formed from feed-water at a temperature not higher than that of the exhaust and, therefore, the heat expended, per pound of steam worked, is greater than in the case of the Carnot cycle by the quantity of heat required to raise the temperature of the water from that of the feed to the boiling point under initial pressure. In the case of the real engine cycle, the expenditure of heat, per pound of steam used, is equal to the total heat of steam at the initial pressure, minus the heat in the feed-water. The respective efficiencies of the two cycles are not in the ratio of the heat expended per pound of steam worked through the engine, for, in the ideal cycle of the actual engine, more work is done per pound of steam used than in the former case. This excess of work is not as great, however, as the excess of heat required to perform it, so that the resulting efficiency of the Carnot cycle is still the greater.

The efficiency of any engine is expressed by the work done per pound of fluid used, divided by the heat expended in doing this work, both quantities being taken in the same units. A much simpler expression was used in computing the efficiency of the Carnot cycle, but it does not apply to the actual engine cycle, and the more general method must be used. We assume that no losses occur other than those due to the cycle and the thermodynanic loss common to all cycles with the same range of temperatures. The expansion of the steam after cut-off is adiabatic. With adiabatic expansion of one pound of steam, through the range given above, the net work per pound of steam expressed in foot-pounds is 227,140. This is equivalent to $227,140 \div 778 = 292$ British thermal units. The total heat of steam at 136 pounds pressure is 1189 thermal units above 32° F., and the heat returned to the boiler by the feed water is about 110-32 or 78 thermal units. Therefore, the heat expended per pound of steam is $1189-78 = 1111$ heat units, and the efficiency of the engine would be $\frac{292}{1111} = 0.263$, nearly, or 26.3 per cent. against 29.5 per cent. for the Carnot cycle with a similar range of temperatures. The steam consumption per horse-power per hour for a perfect engine, operating in the cycle of the actual engine, is found as follows:



THE MILWAUKEE PUMPING ENGINE. THE "RECORD BREAKER" IN STEAM ECONOMY.
BUILT BY THE E. P. ALLIS COMPANY, MILWAUKEE, WIS.

The work done per pound of steam was found to be 227,140 foot-pounds; the work of one horse-power per hour is 1,980,000 foot-pounds; therefore, this perfect engine, operating as assumed, would require 1,980,000 ÷ 227,140 = 8.72 pounds of steam per indicated horse-power per hour. The Milwaukee engine required 11.67 pounds of steam per indicated horse-power per hour, or about 134 per cent. of the steam required by the perfect engine, working between the same limiting pressures. It should be noted that in the above computations the expansion was assumed to be carried down to the exhaust pressure. This was not the case in the actual engine, nor is it desirable that this should be done in a practical engine, for, while complete expansion gives a greater amount of indicated work for a given range of pressures, the economy in effective work delivered by the engine is not increased by carrying expansion below a pressure somewhat above this. Basing our calculation upon the steam consumption of the real engine, and upon the efficiency and theoretical steam consumption of this perfect engine, the efficiency of the Milwaukee engine is found to be $.263 \times \frac{8.72}{11.67} = .195$

or about 19.5 per cent.; that is to say, the actual engine utilizes 19.5 per cent. out of a possible 26.3 per cent. of the heat energy delivered to the engine. The efficiency of the fuel is of course considerably less, owing to losses of the boiler and incidental wastes between boiler and engine.

A comparison has been made between the highest recorded performance of an actual engine and that of a perfect engine working in a similar cycle between the same pressures. This comparison has served to show the margin for improvement on the best present practice, working with no higher steam-pressures than those used with the existing engine. It has frequently been found easier in the past, however, to effect a gain over previous practice by increasing the range of pressure and temperature worked through, or, in other words, by cutting down the thermodynamic loss, rather than by reducing the other losses without a change in the range of working. It will readily appear, when one considers the almost infinite pains that have been taken to reduce the losses through friction, radiation, cylinder condensation, and imperfect steam distribution to a minimum, that never before was it so difficult to secure a closer approach to the ideal cycle, and that if the present type of engine is to give much better economy, this result will probably be attained mainly through an increase in the range of pressures,—that is, by a reduction of the thermodynamic loss. It is evidently impossible to reduce the exhaust pressure by any considerable amount and any important gain of increased range must be secured by the use of higher initial pressures. To indicate the effect of such an increase in pressure as we have assumed to be possible in the near future, the efficiency of the perfect engine with 136 pounds pressure, will now be compared with the efficiency of a perfect engine working in a cycle of the same nature, but with an initial pressure of 500 pounds, absolute. The temperature corresponding to this pressure is about 467° F., or 929° absolute. The lower temperature will be taken at 110° F., as before, or 572° absolute. With the pressures and temperatures now under consideration, the efficiency of a Carnot cycle would be $\frac{929-572}{929} = 0.384$, or 38.4 per cent. Working in the ideal cycle of the real engine, the work performed per pound of steam expended is 299,200 foot-pounds. This is equivalent to $299,200 \div 778 = 384.6$ British thermal units. The total heat of steam at 500 pounds absolute pressure is about 1224 heat units above 32° F., and the heat in the feed-water is 78 heat units above 32° F., as before. This gives for the heat expended per pound of steam used, $1224-78 = 1146$ heat units. Therefore the efficiency in this case is $\frac{384.6}{1146} = 0.327$, or 32.7 per cent., as against 26.3 per cent. with steam at 136 pounds pressure, working in a similar cycle. It is thus seen that by an increase of steam pressure from 136 to 500 pounds absolute, the perfect engine would utilize an additional 6.4 per cent. of the total energy of the steam delivered to the engine, or the ratio of indicated work, for a given expenditure of heat, is as 5 to 4 nearly. The steam consumption per I. H. P., per hour, with the perfect engine, at 500 pounds pressure, is $\frac{1,980,000}{299,200}$, or 6.28 pounds. It should be noted, however, that it costs more, in heat, to generate a pound of steam at 500 pounds than it does at a lower pressure, the temperature of the feed remaining the same, so that the reduction in steam consumption per horsepower does not give a true measure of the real gain in economy. The efficiencies as computed above are proper data for comparison.

The actual efficiency of the Milwaukee engine is lower than that of this hypothetical engine with 500 pounds pressure, for two reasons:—its range of pressures is less, and, hence, the thermodynamic loss is necessarily greater; and while probably few other engines have so closely conformed to the ideal cycle in actual operation, there is still a considerable discrepancy between this engine and the perfect standard. A comparison of the actual engine, under the conditions at which it runs, with the ideal engine under 500 pounds pressure, will show the margin upon which engineers may base hopes of a saving over present highest practice. The efficiency of the Milwaukee engine was found to be 19.5 per cent., while that of the perfect engine at 500 pounds has been seen to be 32.7 per cent. This comparison shows that, by raising the pressure to 500 pounds and eliminating all losses, other than those due to the cycle, a saving of nearly 70 per cent. over the best current practice would be obtained. With this substantial reward as an incentive to further efforts, let us consider the obstacles to its attainment.

The Milwaukee engine realizes $\frac{8.67}{11.67} = 0.746$ of the efficiency of the ideal engine with similar pressures, and the corresponding approach to the ideal, with steam of 500 pounds pressure, would demand an efficiency of the real engine of $.746 \times .327 = 0.244$, or 24.4 per cent. This agrees with the comparison of the ideal engine under 136 and 500 pounds pressure, in which it was seen that the increase in pressure resulted in a gain of about 25 per cent. To do as well, relatively, with the high pressure, as has already been done with the Milwaukee engine, it is evident that there must be a corresponding increase in the number of cylinders, if the prevailing type of engine is to be employed.

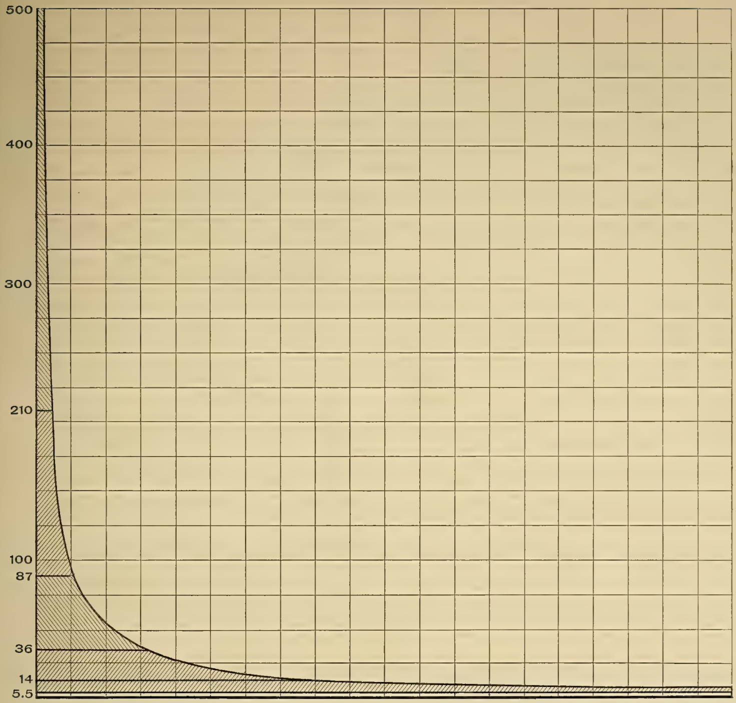
Mr. Reynolds expands steam from 136 to 5.37 pounds in three cylinders; this is a total ratio of expansion of about 25, or an average of about 2.9 in each cylinder. With 500 pounds initial pressure, and the same terminal pressure, the total ratio of expansion would become about 93, and this would require five cylinders to keep the expansion in each cylinder as low as it is in the Milwaukee engine. Five cylinders would give a somewhat lower ratio per cylinder than in the triple expansion, but four cylinders would give much higher mean ratios, and it is probable that five would be necessary to secure as good economy relative to the ideal engine as has already been obtained by Mr. Reynolds in the Milwaukee engine. Upon this basis the following table shows approximately the distribution of pressures between the five cylinders:—

	1st Cyl.	2d Cyl.	3d Cyl.	4th Cyl..	5th Cyl.
Initial pressure.....	500	210	87	36	14
Terminal pressure..	210	87	36	14	5.5

The ideal diagram for this quintuple-expansion engine, in accordance with the assumptions made, is given on the opposite page.

In an actual compound engine there are always losses between the adjacent cylinders, due to receiver-drop and resistance to the flow of steam through the passages, and this is a source of loss that must increase with a greater sub-division of the total expansion. The frictional resistance will also presumably become greater, and the radiation losses and other incidental wastes will be augmented, so that the assumption that the ratio of the real engine efficiency to that of the ideal will be as high in the "quintuple-expansion" engine with 500 pounds initial pressure, as it is found to be in Mr. Reynold's engine, is rather too favorable, unless considerable advance is made in designing. Even supposing this advance to be realized, so that the quintuple-engine demands but twenty-five per cent. more steam than the ideal, we find an engine with five cylinders, complete, with twenty independent valves, presumably, and having a general multiplication of details. The machine becomes extremely complicated and expensive, both in first cost and in maintenance. Where is this to stop? Are we to continue adding cylinders indefinitely? The apparent lesson of the history of steam engineering, as already pointed out, is that steam pressures will be gradually increased. The almost equally apparent lesson of recent history is that cylinders will continue to increase and multiply upon the face of the earth.

This difference exists between the two lessons, however, the increase in steam pressure is clearly necessary for much higher economy, and, in accord-



IDEAL DIAGRAM FROM A QUINTUPLE EXPANSION ENGINE.

ance with this necessity, pressures have increased since the early days of the modern engine; compounding, on the other hand, is only one of the possible expedients for utilizing, economically, the higher pressures. The compound engine, it is true, is almost as old as the modern engine, but it began its present life only a few years back, when a crisis was reached and something had to be done. Deductions from the observations of this limited period are not so reliable as those extending over a century or more, and it seems by no means evident that the coming crisis must be met by the same expedient that served so admirably in the earlier emergency. Higher pressures and ratios of expansion seem essential to advancement, and with these there must come some method of reducing, or at least of checking, the internal losses which accompany our present system. Is the principle of compounding our only salvation? In view of the failures of earlier and abler prophets, the author is conscious of the dangers of prophecy. He is also much impressed with the desirability of increasing steam pressures and ratios of expansion, without correspondingly increasing the number of engines to secure their benefits. He therefore ventures to predict only that engineers in the future will be equal to the emergency as they always have been in the past.

The reciprocating steam engine has proved itself so immeasurably superior to all other forms of prime motors for general use, that it is almost treasonable to intimate that it may ever be deposed. The rotary engine, as the term is ordinarily used, notwithstanding its peculiar advantages, has not been even a tolerable success, and if its mechanical defects should be overcome,—which seems highly improbable,—it is subject to losses by cylinder condensation and re-evaporation due to the exposure of metallic surfaces to steam of varying pressures and temperatures.

The newest, yet oldest, form of steam motor, the steam turbine, is free from this inherent and very serious defect of the reciprocating engine. In its operation, the various portions in contact with the steam are exposed to constant, or nearly constant, temperature.

This temperature may vary, and does vary, from point to point, but the frequent periodic fluctuations of temperature at any one point is absent. The great loss, through alternate condensation and re-evaporation, is not ameliorated ; it is eliminated.

It is usually better to avoid an evil than to partially counteract it.

Most engineers who noticed that modest little contrivance in Machinery Hall at the recent Chicago Exposition, —the De Laval steam turbine,— must have been impressed with its simplicity. Essentially, it consists of two pieces (and no mechanism can have less), a wheel and its axle, with a suitable frame or support. It uses steam of high pressure, expanding it before it is used. The energy of the steam is transferred by free expansion into the kinetic energy of a mass in motion ; and the impact of the particles of steam, or water, against the vanes is, in brief, the method of utilizing the energy stored in the steam. It is not a pressure engine, but an impact motor, analagous to the familiar Pelton water-wheel. This motor of 20 horse-power could almost be packed in a common "grip."

But this latest aspirant for a share in the work of the world has its defects. Man's creations, like all men, resemble each other in one particular,—all have their shortcomings. The electrical development of a dozen or more years ago called for higher speeds, and greatly stimulated the now prolific family of "high-speed" engines. In this field, especially, could the new type compete on favorable terms with its more dignified predecessor, the slow-moving, long-stroke, engine. The troublesome jackshaft partially compensates for the better economy in indicated work of the larger engines. With the steam turbine we again find ourselves encumbered with mechanism of transmission, interposed between the motor and the machine to be driven; but, in this case, the intermediate mechanism is required to "gear down," or to reduce the speed of revolution.

The present turbine is economically impossible except at extremely high rotative speeds, speeds many times too great, even for dynamo driving. In the little De Laval motor, the very compact reducing mechanism is the largest part of the machine, and still there is difficulty in getting sufficiently high speed of steam disc and sufficiently low speed of delivery shaft. In the small motors shown at Chicago, it must be admitted that skill in design and construction overcame this difficulty to a considerable degree, but the mechanical difficulties incident to such high speeds are great, and they would be magnified should this motor attempt to compete seriously with the orthodox engine of large capacity. It is claimed that this little motor of 20 horse-power has developed a horse-power with about 19 pounds of steam per hour. This performance is about equal to that of our high-speed, compound, condensing engines,—a truly remarkable and suggestive showing, if it be borne out by further trials. The De Laval turbine has been singled out for discussion as being the latest to attract general attention in this country, and as, perhaps, the most radical departure from established practice. We have become more or less familiar, through the technical press, with the American Dow, and the English Parsons turbines, and experiments with the latter, a year or more since, attracted much attention. Though these differ somewhat from the De Laval engine, they have the corresponding general advantages and disadvantages of the Swedish motor. It would be premature to even intimate that the reciprocating engine will be brought into serious general competition with the steam turbine; yet the manifest impossibility of completely eradicating the evil of internal condensation and re-evaporation from the ordinary engine, and the immunity of the newer form from this hereditary disease, has led many thoughtful engineers to look upon it as a thing of considerable promise.

The steam turbine makes a short cut past multiple cylinders, steam-jackets, super heaters, and non-conducting surfaces, and, great as the obstacles in its path undoubtedly are, they are mechanical in their nature, and such obstacles are seldom as obstinate in yielding to skillful treatment as the thermal wastes of the engine cylinder have proven.

The writer disclaims any insight into the solution of the problem which confronts us—the reconciliation of the conflict between the economical use of very high pressure steam and simplicity of mechanism, and the steam turbine has been introduced into the discussion, not as a demonstrated means of deliverance, but because it seems to be an expedient presenting the semblance of serious claims to consideration.

We know that some evils must be endured, though nearly all can be ameliorated. In any heat engine we believe definite thermodynamic losses to be inevitable, and we know that frictional losses in any machine can never be reduced to *nil*. The steam turbine demonstrates that the phenomenon of cylinder condensation and re-evaporation is not of the species *must be*, and if it ends with emphazing this fact, it has perhaps performed a by-no-means insignificant mission. It is not at all certain that other practical motors, differing as radically from the turbine as it differs from the present standard form of engine, may not be be brought out. It does seem rational to believe, however, that the ultimate and only satisfactory solution of any problem involves not the mere restriction, but the absolute suppression, of such prejudicial elements as natural laws do not make inevitable.

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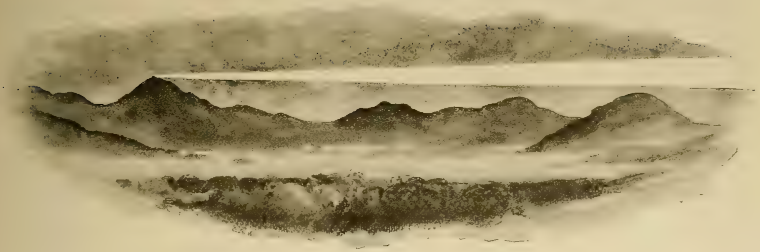
OBSERVATORY WITH SEARCH LIGHT EQUIPMENT ON THE TOP OF MT. WASHINGTON.



SEARCH LIGHT ON THE TOP OF MT. WASHINGTON.

LARGE SEARCH LIGHT PROJECTORS.

By H. M. Norris, Jr. Am. Soc. M. E.

THE electric search light projectors in operation at the World's Columbian Exposition seem to have attracted far more attention and widespread interest than any other electrical feature of the Fair. These lights, I believe six in number, occupied the most prominent positions upon the roofs of the buildings, which gave them the command of the entire grounds and lake front. Four of these, forming a part of the exhibit of Schuckert & Co., of Nuremberg, Germany, were placed at each corner of the promenade built upon the middle of the Manufacturers' Building, 240 feet from the ground. In the darkness of night the roofs and apparatus were invisible. Nothing could be seen but the glowing reflectors and their white beams of light, appearing from a distance like so many chained but restive comets, or like windows in the heavens, casting far-reaching rays of brilliant light upon the dark world beneath. The diameters of the projectors in these lights were two, three, four and five feet respectively. Under favorable circumstances the light from the largest one could be seen from a distance of 100 miles, and with the aid of a field glass a person standing by its side would have been able to distinctly follow the movements of a war vessel or a regiment of soldiers, under fire of the light, twenty miles away, while any one ten miles distant could have read a newspaper with comparative ease.

It is only within a very few years that these results have been accomplished. After the first use of commercial arc lights, about fifteen years ago, many experiments were tried by which the intense light of the electric arc might be collected and thrown in a single direction, to a distance otherwise unattainable. The first mirrors experimented with were made of metal. These, it was found, could not be constructed accurately enough in the form of a paraboloid of revolution to accomplish the desired purpose, and it was also found that they soon deteriorated through oxidation, and from the frequent cleanings necessary. The difficulties of constructing glass parabolic reflectors, which appeared until quite recently insuperable, led Mangin to invent his well-known reflector, and induced others to construct their reflectors as an approximation to the parabolic form.

Schuckert & Co., with the collaboration of Prof. Munker, were the first to

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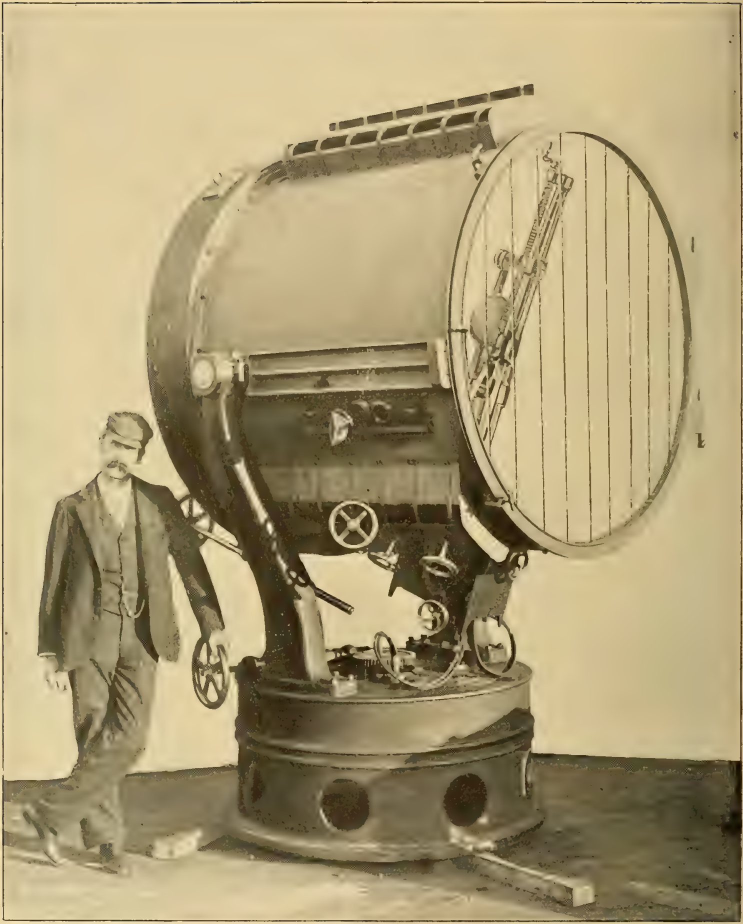
FROM A SEARCH LIGHT PHOTOGRAPH OF LIZZIE BOURNE'S MONUMENT ON THE SUMMIT OF MT. WASHINGTON.

completely overcome the difficulties, and to build the huge projectors of the present day, in which a semi-spherical mirrored lens of the finest glass catches every ray of light from the white-hot crater of the positive carbon, multiplies them by five and sends them out through space in parallel lines. Their largest light stands eight and one-half feet in height, has a surface intensity of light of 14,000,000 candle power, requires a current of 150 ampères at sixty volts and consumes twelve electrical horse-power. The parabolic glass mirror has a working diameter of five feet, with a thickness of seven-eighths of an inch. It is ground and polished on both sides and has its back covered with a heavy coat of silver, protected by a specially prepared paint. It is held in position in the drum by means of springs so as to provide for expansion and contraction, due to heat on one side and cold rain or snow upon the other. In order to make it easier for the attendant to observe the position of the carbons and form of the crater while the apparatus is in use, and to enable new carbons to be inserted when required, small optical projectors are arranged at the side and on top of the casing, which throw images of the arc, as seen from above and from the side, upon a plate of ground glass fixed in the side of the casing. The lamp is of the automatic type, that is, the feed of the carbons is accomplished, and the arc established, automatically, so that it is simply necessary to turn on the current to get the full force of the light at once. The carbons may be adjusted to project either a convergent or divergent beam, moving them toward the mirror producing the divergent beam, and moving them away from the mirror producing the convergent beam. By means of small electro-motors, placed in the frame, the projector can be controlled from a distance, such as the bridge of a ship. The switch is so arranged that the current can be passed into the armatures of the motors in either direction, giving any movement that the observer may desire. The projector is thus under the direct control of the officer on watch, so that mistakes in carrying out orders are entirely avoided.

The uses to which the search light can be put are constantly increasing. Communications written in stencil upon sheets of tin can be used as lantern slides in the larger sizes of projectors, which, thrown upon the clouds, as upon a huge canvas, are easily read a mile or two away. As an aid in ship navigation their value is inestimable, although, at the present time, lamps of the higher candle power are used mainly upon the decks of men-of-war, forming an important factor in the fighting efficiency of these vessels. Over three hundred and fifty of these lights, manufactured by Schuckert & Co. alone, are now in use in foreign countries for fortifications, as well as for the merchant service and navy. They were used by the Italian expedition to Massowa, mounted on special wagons made for the purpose. The future will probably find them extensively used for the more peaceful purposes of scientific research, long-distance signaling, and even of general illumination.

To America, however, belongs the credit of having constructed the largest and most powerful electric search light in the world. This light was turned out from the works of the General Electric Company and was shown by them at the World's Fair last year. Some idea of its size may be gained by the comparison made between it and the man of ordinary height standing by it, shown in the illustration from a photograph taken when the search light stood on the roof of the factory. It stands about ten feet six inches high to the upper side of the ventilator on the top of the drum, and the total weight is about 6000 pounds, but so perfectly is it mounted and balanced, that a child can move it in any direction. The reflecting lens mirror used in this projector is 150 centimetres, or sixty inches, in diameter. It is a concave spherical mirror of the Mangin type, free from spherical aberration, reflecting a sensibly parallel beam of light. It was manufactured especially



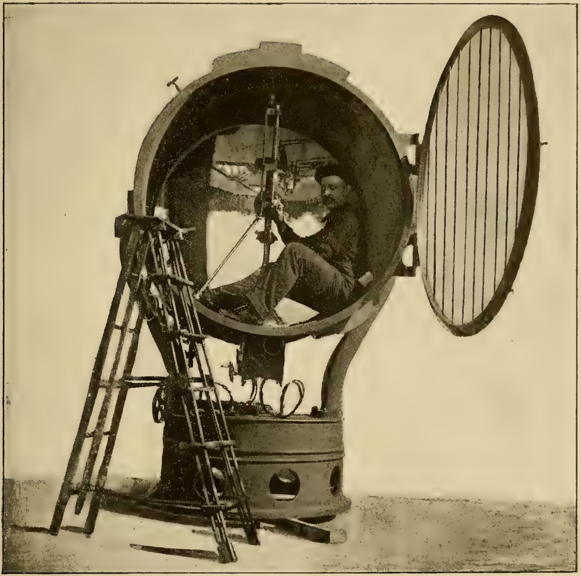
THE LARGEST SEARCH LIGHT IN THE WORLD.—THREE HUNDRED AND FIFTEEN MILLION CANDLE POWER.

for this projector at Paris, France, and is a most perfect specimen of optical work, three and one-fourth inches thick at the edges and one-sixteenth of an inch thick at the centre, and weighs about 800 pounds. The metal ring in which it is mounted weighs about 750 pounds, and the total lens, ring and cover weigh about 1600 pounds. This great mirror is mounted at one end of the big drum, the outer end of which is furnished with a door consisting of a metal rim, in which are fixed a number of plate glass strips five-sixteenths of an inch thick by six inches wide.

Inside this drum and sliding upon

ways arranged on the bottom, is placed the electric lamp,—the source of the light which is reflected by the mirror. It is entirely automatic in its action, is six feet high and weighs about 400 pounds. The carbons used are also made especially for it. The upper or positive carbon is one and one-half inches in diameter and twenty-two and one-half inches long, with a five-sixteenths of an inch core of soft carbon running from end to end through its centre. The lower or negative carbon is one and one-fourth inches in diameter, is fifteen inches long, and also has a core of soft carbon running through its centre. In addition, its outer surface is heavily coated with copper. The positive carbon is set a little in front of the negative and thus almost all the intense light of the incandescent crater is cast upon the reflector. The maximum current at which this lamp operates is 200 ampères, and at this current the lamp has a luminous intensity of about 90,000 to 100,000 candles, and the reflected beam a total luminous intensity of about 375,000,000 candles, an intensity which the eye cannot appreciate.

In looking at the side of the beam the spectator distinguishes only a stream of light of comparatively low intensity, but in looking at the beam directly, its brilliancy is fully seen, and the effect is absolutely blinding. Ventilators at the top and sides allow a constant current of air to pass through the drum and dissipate the heat generated by the arc lamp, and they are so arranged that no light can escape through them. All the connections for adjusting the positions of the carbons and the lamp are brought through the drum to the outside, and are arranged in close proximity to one another at one side so that all may be manipulated by



ANOTHER VIEW, ILLUSTRATING THE SIZE OF THE REFLECTOR.

the operator without moving from his position. Through openings in the drum, covered by densely colored glass, the operation of the lamp may be watched, and its adjustments verified. The drum is supported by trunnions in bearings at the top of a Y-shaped fork, set in a base plate, and the whole is supported on a system of friction wheels, forming a turntable resting upon the top of a massive pedestal supporting the whole structure. The drum, fork and base plate may be rotated horizontally on the turntable either by hand or by gearing provided for this purpose. The drum may also be elevated or depressed in a vertical plane by similar gearing.

Before the projector was sent to the World's Fair, a public test was made at Middletown, Conn. From the roof of the works the great white beam of light shot forth into the obscurity of the night, and slowly swept the countryside for miles around, bringing every object upon which it was directed into brilliant and distinct relief. It illuminated the roofs of distant villages and scared their inhabitants, and lighted up the sign boards miles away, so that they could easily be read by means of a glass. The projector was turned upward toward the sky, and the beam, like a supernatural divine finger, wrote words upon the clouds—messages of light to the starry populations. It was a majestic manifestation of man's invasion of the realms of Phœbus.

It was observed that the space within the beam was violently agitated, and closer observation revealed the fact that millions of moths and minute insects were hovering in it, attracted by the brilliancy of the light. Next morning bushels of dead moths, beetles, other insects, and some small birds, were swept up from the roof on which the projector stood. They had been killed by the intensity of the light. How far the powerful beam of light of this instrument can be seen is difficult to state.

The search light set up by the General Electric Company on Mt. Washington in the White Mountains, has a diameter of only thirty inches, and a reflected light from the mirror of about 100,000 candle power, yet a newspaper can be read in its beam ten miles away, and the light can be seen from points 100 miles away. During the months in which this light was in operation, it was frequently used in sending messages to distant points, the messages being returned to the mountain for verification, by means of the ordinary telegraph. Portland, Maine, at a distance of over eighty miles, was thus communicated with several times. During the later portion of the summer a set of weather signals were agreed upon, and the light was used nightly to give to the surrounding country the local weather indications, as made up at the United States Signal Station on the top of the mountain.

The idea of placing a powerful search light at a vantage point of this kind was certainly a novel one, and it is hoped that some remarkable results in the line of long-distance projection of light will be attained as outcomes of this installation.

A GLIMPSE OF FAYETTEVILLE.

TECHNICAL SCHOOLS OF AMERICA.—IV.

THE ARKANSAS INDUSTRIAL UNIVERSITY.

By Professor C. V. Kerr.

FAYETTEVILLE is a town of nearly 4000 people, located among the hills of northwest Arkansas. Sheltered by the low range of Ozark mountains on the north and by the Boston mountains on the south, this part of the State is quite secure from the biting winds of winter and the hot blast of summer. The temperature seldom approaches zero, or reaches far into the nineties, the average being 58 degrees. The rainfall amounts to about 50 inches and is quite evenly distributed through the year. The soil is fertile in the valleys, though rocks and clay make farming a burden on the hillsides. Yet this part of the State is already widely known for fruit, and the names of the "Arkansas Black" and the "Shannon Pippin" arouse pleasant recollections and inspire lively hopes. About Fayetteville a large part of the hill surface is covered with timber, while the valleys are cleared and yield rich crops of wheat and corn. Within the town are two springs, one of which flows 50,000 gallons or more of water per day, and the other, perhaps 20,000. There are also mineral wells of decided medicinal value. The town itself lies nearly 1400 feet above sea level, and on its eastern border "East Mountain" rises to a height of over 1700 feet. From points on the summit of that mountain, picturesque views of hill and orchard, valley and wheatfield will repay a toilsome climb. The population is rather cosmopolitan in texture, representing not only the chivalry of the South, but the culture of the East, the business energy of the North and the alertness and dash of the West.

Such is the setting of the Arkansas Industrial University. Like many of

SHOP BUILDING AT FAYETTEVILLE.

INTERIOR OF THE FORGE AT FAYETTEVILLE.

the best institutions of the country, it was founded upon the Land Grant Act of 1862. Twenty odd years ago, when the beginning was made, the State was exhausted and poor, and the town, as yet without a railroad, numbered but a few hundred people. In order to secure students, courses of study were prepared that practically covered the whole of student life,— from charts and first reader to metaphysics. As the institution grew stronger, and the public school system developed, the lower classes were discontinued. But even now, after twenty years of growth, from the fact that a large section of the State is without the advantages of high schools or academies, it is necessary to reach down to the level at which the district schools leave their pupils.

The standard of admission to the University is now fixed at algebra to quadratics, and plane geometry,— a standard somewhat lower than that maintained by the majority of the leading schools. Still, a school to be most efficient must be best adapted to the material upon which it is to work, and the courses of study have been so shaped that the young men and women of the State, with their limited means, could secure the education desired and find themselves, at the end, well fitted for their chosen work.

Until the passage of the Morrill Bill in 1890, by which a portion of the proceeds of the public lands are devoted to the support of colleges giving instruction in agriculture and the mechanic arts, the University was dependent, aside from local revenues, upon appropriations made by the State Legislature, and while in general those who receive should not criticise, yet those who are familiar with the practice of legislatures in making such appropriations will recognize in that support the basis for only a precarious existence. The Legislature is composed of men from all parts of the State who meet once in two years to attend to public business. These men may be intelligent and actuated by patriotic motives, but they frequently know nothing of their State University and, hence, do not realize its needs. The history of the University records a time when it was saved by a piece of righteous strategy from

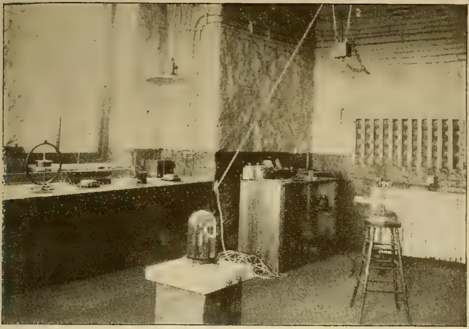
THE MAIN UNIVERSITY BUILDING.

the necessity of closing its doors, for a time at least, through failure of appropriations. It is said that oak fibre grown upon an exposed mountain side is stronger and more elastic than that grown in a sheltered valley. Is it not also true that the mountain oak is apt to be more knotty and gnarled and wind-shaken than its neighbor of the valley? However, either in spite of or by virtue of these adverse circumstances the University has grown stronger and larger and more efficient.

As at present organized, the University comprises at Fayetteville the Colleges of Mechanic Arts and Engineering, of Science, of Liberal Arts, the Normal and Agricultural Schools and the Experiment Station, in which are thirty-four officers and instructors, with a total enrollment, for last year, of five hundred and fifty-six students. At Little Rock is the College of Medicine, with seventeen instructors and one hundred and thirty-eight students. At Pine Bluff are the Normal and Mechanical Schools for colored boys and girls of the State, with six instructors and two hundred and thirty-four students. The total number of instructors for last year was fifty-seven, and of students nine hundred and twenty-eight. Of the colleges at Fayetteville, that of Mechanic Arts and Engineering stood first last year in numbers of male students, with the School of Arts second, and the School of Science third. In numbers of female students, the School of Science was first, and the School of Arts second.

The College of Mechanic Arts and Engineering offers courses in civil, mechanical and electrical engineering and "trades courses." The material equipment for instruction in these courses follows the usual lines in providing shops, laboratories and surveying instruments. The shop building, erected in the spring of 1889, is of corrugated iron, 170 feet long, 40 feet wide and one-story in height. During the fall of 1892 an addition to the shops, 20 x 40 feet, was put up almost entirely by students. The wood shop, 40 x 60 feet, is equipped with eighteen work benches, with tools, seven turning lathes and a pattern maker's lathe, double circular saw, scroll saw, band saw, shaper, planer and trimmer. The forge shops, 40 x 25 feet, contain seven anvils and forges with complete sets of tools, and a post drill. The forges are supplied with blast from a pressure blower, and the smoke is drawn off by an exhaust fan. The foundry is equipped with an 18-

THE ENGINEERING LABORATORY.

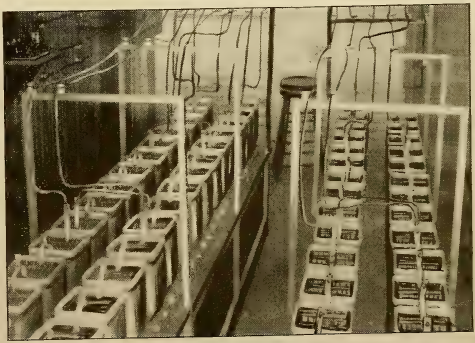


THE ELECTRICAL LABORATORY.

inch Colliau cupola, capable of melting 1000 pounds of iron an hour; a brass furnace, sand troughs and molders' benches, core oven, molders' tools, flasks, ladles and other necessary apparatus for instruction in iron and brass casting. The machine shop contains work benches and vises, four engine lathes, a speed lathe, two planers, a shaper, a universal milling machine, a cutter grinder, an emery grinder, a drill press, and the usual tools and appliances for use with such machines. A 25-horse-power high speed engine supplies the necessary power.

The boiler room contains two 40-horse-power horizontal flue boilers, and a 60-horse-power return tubular boiler. A pump and two injectors are arranged so that any one may be used to feed any boiler. Two feed water heaters are piped, so that the first uses exhaust steam from the engine to heat the feed water to about 200°, which is then passed to the second, whose coils are supplied with live steam. The feed water thus enters the boiler at nearly the temperature of the live steam, while the condensed live steam returns by gravity to the boiler. Seventy students can be accommodated in the shops at one time, as follows: Wood shop, twenty-four; foundry, eighteen; forge shop, seven; machine shop, sixteen; tool room, two, and boiler room, three.

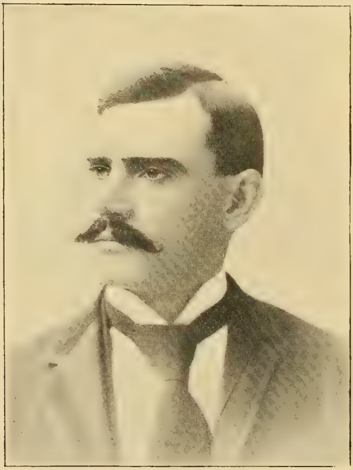
During the past year, the regular course of shop work, which hitherto covered three years, with an average of eight hours a week, and taking the student, in succession, through wood shop, foundry, forge and machine shops, tool and boiler rooms, has been extended to four years. The student desiring a "trades course" is allowed to spend the fourth year in that shop which he prefers. During the four years the student is continually under instruction in the class-room as well as in the shop. It is hoped that this plan will produce workmen who will compare favorably in skill, as well as intelligence, with the ordinary three years' apprentice. Those students who desire to become stationary engineers, spend their fourth year in the engine and boiler rooms, learning to fire the boilers, run the engine, operate the pump and injectors, and manage the steam heating system. So far as



THE STORAGE BATTERY PLANT.

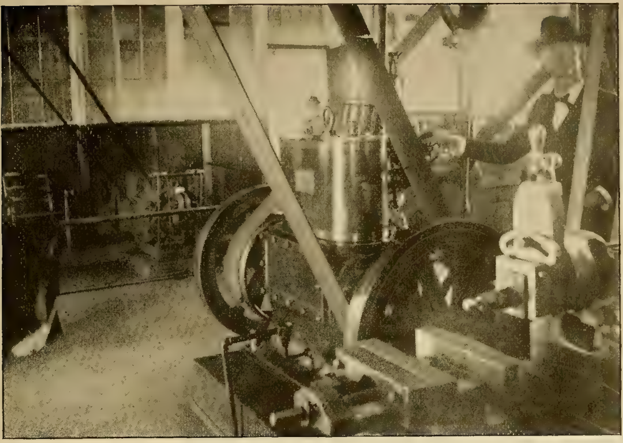
the shop instructors are concerned, the policy is to fill the positions with young men from the University's own shops and from other manual training schools, who have taken the regular course of shop work and afterward made a specialty of some line of work, who, in other words, have intelligently acquired the trade best suited to them. Such men, especially if gifted with an aptitude for teaching, make good instructors. To meet the demand for such instructors in the schools here particularly considered, and in others who want them, the "Manual Training Normal Course" has been established. On the basis of a good English education, the student is instructed in pedagogy, school management, history of education and school law. He takes also the regular shop course during the first three years. Then, during the fourth year, instead of the usual practice teaching in the class-room, the student has practice in shop teaching, and studies shop organization and equipment.

What has thus far been said of the organization for manual training applies equally to the shops for white boys at Fayetteville, and to the shops for colored boys at Pine Bluff. The shop building at Pine Bluff is of brick, and the equipment is planned to provide work for fifty students at one time. Two thirty horse-power return tubular boilers furnish steam for heating and power. The machinery is run by two twelve horse-power vertical engines. The exhaust steam there, as well as at Fayetteville, is used to heat the shops in addition to heating the feed water for the boilers. The wood shop contains twelve work benches with sets of tools, seven turning and pattern lathes, a double circular saw, scroll saw, and buzz planer. The foundry has a cupola capable of melting one ton of iron an hour, and a suitable equipment in accessories is being secured. The forge shop contains twelve forges with full sets of tools, a post drill, a punch and a bar cutter. Power blast and exhaust are provided for the forges. The machine room contains two engine lathes, a turret lathe, speed lathe, planer, universal miller, shaper, cutter, twist drill and an emery grinder, with work benches and the necessary small



G. C. SCHOFF, B. S., C. E., LATE ADJUNCT PROFESSOR OF CIVIL ENGINEERING.

C. V. KERR, PH. M., M. E., PROFESSOR OF MECHANICAL ENG'G. AND EXP. MECHANICS.



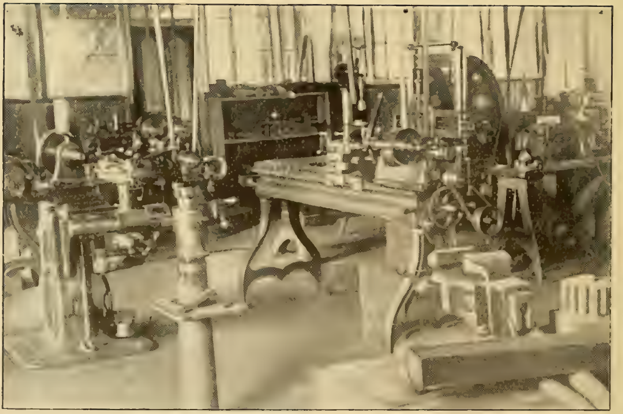
ENGINE AND DYNAMO ROOM AT FAYETTEVILLE.

tools. An artesian well of 1000 gallons per hour capacity supplies water, and a complete private sewerage system takes off all waste.

In the days when the classics formed so large a part of the means to an education, a teacher, a book, and a bench were the essentials. As there was but little choice between books and benches, the questions asked by those who made an intelligent choice between schools referred largely to the character and talent of the teachers. At present, however, the recognition of the value of technical education, which must of necessity rest upon material equipment, has caused a change in the drift of questions asked concerning a school. One will hear the question, How are the shops and laboratories equipped? quite as often as, Who are the teachers? Hence, it will be proper to describe the equipment for the higher education in civil, mechanical and electrical engineering, as well as that for instruction in the mechanic arts.

Aside from the usual furniture provided for the drawing room, such special apparatus and instruments may be mentioned as the planimeter, pantograph, blue print frames, traverse table, odontograph, slide rule, sets of railroad and machine curves, and root pitches. For the work in railroad, land and city surveying, the equipment provides chains, tapes, plumb bobs, a

W. E. GOLDSBOROUGH, M. E., ADJUNCT PROFESSOR OF ELECTRICAL ENGINEERING.



MACHINE SHOP VIEWS AT FAYETTEVILLE.

Locke level, an aneroid barometer, a sextant, a Y level, transits with solar attachment, plane table, etc. Not the least valuable accessory is a surrounding country which offers problems in most of the varieties of work which meet the practical surveyor. Each year, during the summer, a party of engineering students goes into camp for a week of practice in surveying and locating railway lines, and as the course in surveying extends over three years, each student has the benefit of three weeks in this practical work.

A CORNER IN THE PINE BLUFF FOUNDRY.

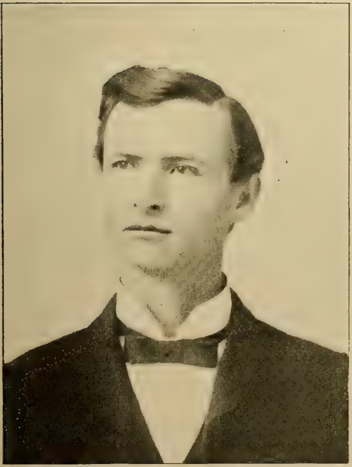
Opportunity also is afforded for experimental boiler work. The heating power of coal is ascertained, the amount of moisture in the steam is determined by a calorimeter constructed in the shops, and a feed pump and an injector are so arranged that comparative trials may be made of their efficiency as boiler feeders. The engine used to run the shops and electric light plant affords practice in measurement of power by the indicator and the Prony brake. A testing machine, run by a ten horse-power motor, and capable of exerting a pull or pressure of 60,000 pounds has been installed, and is used in experimental work upon the materials used in buildings, bridges and machinery. A practical application has been made in determining the tensile strength of the steel plates used in the two thirty horse-power boilers for the Branch Normal shops at Pine Bluff, and the sixty horse-power boiler for the University shops. A 2000-pound cement testing machine is used to determine the tensile strength of various cements and their resistance to crushing. A saw for stone cutting has been designed and constructed for

THE PINE BLUFF SHOPS.

INTERIOR OF THE FORGE SHOPS AT PINE BLUFF.

the purpose of cutting out specimens for tensile and crushing tests. A complete incandescent electric light plant has been installed and is used for lighting the main building, and for experimental work. A 180-light dynamo and a ten horse-power motor supply power to run the machinery of the laboratories and current for lighting the buildings. A storage battery capable of supplying a current of 110 volts for thirty incandescent lamps of sixteen candle-power each is also in use.

The principles on which the course of study and the methods of instruction were based have been expressed thus: "The courses in engineering offered are designed to supply not only mental training, but the means for insuring a livelihood in the profession to which they lead. It is believed that the most efficient way to teach theory is to unfold it to the student only so fast as he can apply it to the practical work of his course. He thus makes it his own, and theory becomes practice." To discuss courses and methods in detail would be tedious and the requirements of this article will be satisfied by dwelling upon a few prominent points. All students in engineering, whether civil, mechanical, or electrical, are required to take the three years of general shop-work, and a one-year course in the theory and practice of surveying—the work for the civil engineers extending over three years; mathematics and mechanics, as well as drawing, form lines of work which continue throughout the several courses. Physics, chemistry, laboratory and other experimental work have the usual place and proportion. English is the only language taught, but the purpose is to teach that thoroughly and thus give the students a good command of their mother tongue. The engineering students are further encouraged, though not required, to join one of the literary societies and thus acquire some skill in debate and oratory, as well as a knowledge of parliamentary law. Toward the close of the course the engineers take up the general laws of business, comprising law of sales, agency, partnership, contracts and patents. An application is made at once in preparing the form of contract and the specifications for some project in the chosen line



M. MARTIN, B. M. E., FOREMAN OF SHOPS AT FAYETTEVILLE.

W. S. HARRIS, FOREMAN OF SHOPS AT PINE BLUFF.

of work. The keystone of the student's arch is the "Thesis," an original work planned and executed by the student. There are at present no electives in the engineering courses, though students who seem capable of carrying an additional load are allowed to take studies outside of their regular course, especially those closely allied. The plea for this policy is a desire to prepare for the student a basis for his life work, selected and put together with more mature judgment and greater skill than that of the average student. Encouraging reports come from employers of the engineer graduates.

C. V. Kerr, professor of mechanical engineering and superintendent of mechanic arts, graduated from the Western University of Pennsylvania in 1884. After a year spent in railroad surveying, drafting and private study he entered Stevens Institute of Technology and graduated as mechanical engineer in June, 1888. During the last year there he served as assistant in the chemical laboratory and in experimental mechanics. The next year was spent as a teacher of mathematics and science in the manual training department of Pratt Institute. The fall term of 1889 was spent in Sibley College at special work in electrical engineering. Beginning January, 1890, as assistant professor of engineering in the Western University, he outlined the course of study for the degree of mechanical engineer, and equipped the shops. Since April, 1891, he has held his present position, during which time the shops for colored boys at Pine Bluff have been planned and equipped. Recently he was elected a member of the American Society of Mechanical Engineers.

G. C. Schoff, until recently adjunct professor of civil engineering, graduated in the scientific course from St. John's College in 1886, and again as civil engineer from the Arkansas Industrial University in 1888. He was with the Memphis, Little Rock & Indian Territory R. R. from October, 1888, to February, 1889, and next, for a short time with the Arkansas Geological Survey. During the following year he was with the Johnson Company, of Johnstown, Pa. The next three years were spent as teacher of civil engineering, surveying and drawing in the University. Vacations were filled as salesman for the Natural Gas Fuel Company of Philadelphia, and with J. N. Whitham of that city, in general consulting practice.

W. E. Goldsborough, adjunct professor of electrical engineering, graduated in 1892 from Cornell University in the electrical engineering course. Before coming to Fayetteville he was professionally engaged with the Colliery Engineer Company in the mining regions of Pennsylvania. He is an associate member of the American Institute of Electrical Engineers. M. Martin, foreman of shops at Fayetteville, graduated as mechanical engineer from the Arkansas Industrial University in 1891. He was at first in charge of the machine shop, but his duties have increased to those of his present position, and to instruction in applied mechanics. W. S. Harris, foreman of shops at Pine Bluff, is a graduate from the Miller Manual Labor School, and he was pursuing an engineering course when he withdrew to act as assistant instructor in the Miller shops. After holding his position for a year he resigned in 1884 to work at cabinet and pattern making for the Roanoke Machine Works. After four years of work with that firm and four more with the American Bridge and Iron Company, he came to Pine Bluff and assumed the duties of his present position in September, 1892.

THE ARTIFICIAL LIGHTING OF WORKSHOPS.

By Benjamin A. Dobson, M. Inst. M. E.

THE use of artificial light in manufacturing districts is of considerably greater importance for work of all descriptions than it can be elsewhere. Whether the work be fine or coarse, delicate or bold, a better light is needed than for work which does not come under the head of manufacture. Just what the requirements for a well-lighted workshop are, was recently outlined by the writer in discussing the subject of this paper before the Institution of Mechanical Engineers of Great Britain.

The light, if artificial, should be sufficiently intensive to give the power of clear and natural sight over any portion of the work. For enabling the work to be performed with ease, the light should evidently be arranged to produce, as nearly as can be, the effect of natural sunlight. The light of the sun is diffused by the atmosphere, and unless its entrance is limited in extent, such shadows as it may produce are only natural shadows—so natural that the eye has no difficulty in following detail in any visible part. In this respect, therefore, artificial light should, as far as practicable, imitate the best natural conditions. The light should be so diffused as to avoid casting shadows or placing any one portion of the work in too great relief, as compared with the general tone of the whole. If the work were being done in front of a window which faced the sun, a certain portion of it would receive an undue amount of light, and give a false idea alike of size and distance, owing to the contrast of the overlighted and underlighted parts. This might be a natural light, but would, nevertheless, be improper.

The light, further, should be of such a character as to have no tendency to injure the sight by a blinding glare. This remark applies either to a good gas flame or to the electric glow lamp, from both of which the light is fairly well diffused ; the rays, being all comparatively weak, are easily diverted, and thus distributed. But the effect of having either a bright gas flame or the still brighter coil of glowing wire before the eyes is exceedingly fatiguing and destructive to the sight, and, in combination with the dust of workshops, makes it a wonder that ocular diseases are not more common than they are. Again, the light should be of such a character as to leave the atmosphere free from noxious emanations. Any kind of natural or electric light will fulfill this condition. The artificial light that most infringes it is gas, which varies much from town to town, and even in the same town from time to time ; but it is generally so impure as to be deleterious to health and comfort in the products of its combustion, which is always more or less incomplete. The light, too, should not unduly raise the temperature of the room in which it is employed. If, on a hot day, a gas burner has to be lit for every person in a crowded workshop, as has to be done in certain manufactories, the combustion of so much gas affects the temperature greatly, and thereby produces lassitude among the workpeople, together with various ailments which are almost in proportion to the amount of gas consumed. Finally, the light should be simple, and capable of easy control. The whole arrangement should be so contrived that nothing but the simplest knowledge and experience are required for turning the light on and off. This implies, of course, both a central control and also various points of sub-central control. The cost also should be kept within such limits as will render the light practicable at the present day for those who have to make their livelihood in their special trade in open competition with the rest of the world.

Some years ago, while engaged in visiting and examining certain mills on the continent, the writer was much struck with a mode of lighting which he then saw for the first time. This consisted in the use of electric arc lamps of from 1600 to 2000 candle-power, suspended in a white enameled reflector at a certain distance below the whitewashed ceiling of the mill. The first he saw was of 2000 candle-power, and thoroughly lighted a large room of about forty feet square with light sufficient to see to pick up a pin off the floor. The walls of the room, as well as the ceiling, were whitewashed. The light had a sort of bluish tinge, and looked like bright moonlight, but with much greater illumination, and entirely without shadows. This appeared so striking that he made a few experiments at once, and found that it was possible to see into the interior of the machines, and even underneath them, in a way that up to then would have seemed incredible ; and, further, that it was not possible to make a shadow of any description, even when holding a hat only two inches above the floor ; all that could be seen in the centre of the covered part was a comparatively slight deepening of the shade. In other departments of the factory he found the same plan equally effective, and the diffusion of the light so complete as to be astonishing.

At that time the author's firm were engaged in replacing gas by incandescent glow lamps, on the Edison–Swan system, in a large machining room at their own works, which is 345 feet long by 76 feet broad, and only 12 feet high, containing 239 machines, tended by 200 workpeople, in the area of 26,220 square feet. The exigencies of trade had required that annexes should be constructed almost round the building, thus further diminishing the amount of natural light that could gain admission. Along the whole of the centre of the shop, for a breadth of some fifty feet, gas was burning day and night, and in the close, muggy weather of autumn, and the fog-laden days of hot summer, the atmosphere of the room became most oppressive, in spite of the best ventilation by Blackman propellers. Even at six o'clock in the morning, on entering the room, the smell was most objectionable. The incandescent glow lamps, each with its own switch, and covered with a wire guard, were attached to the gas brackets, which for this purpose were left just as they had been. Within a week of the application of these lamps, the importance of the requirement, with regard to glare, was amply proved, for every workman had devised a shade of one kind or another, some of white or brown paper, some opaque, and some translucent.

The author was not satisfied with the result of this lighting. The shop was as dark and gloomy as with the previous gas lights. The number of lamps broken by accident and by carelessness was so great as to become a serious consideration, their price being out of proportion to their actual cost, and no allowance being made in regard to royalty in replacing broken lamps which had already paid royalty. The writer then made two further journeys to the continent, in order again to examine the plan of the inverted arc lamp. The second journey was made with the view of going more thoroughly into the details, and concluding arrangements for conducting a trial of the plan in his firm's establishment. On this occasion he had the opportunity of examining a large weaving shed at Ruysbroek, near Brussels, on a dark winter night. Corridors lighted by incandescent lamps led to the vast weaving shed, which had the usual roof containing glass panels almost upright, facing north, with a plastered ceiling sloping southward from the top of each glazed panel, and lighted from an inverted arc lamp in each bay between the pillars. The impression upon entering the doorway was that the large room was brilliantly lighted by the mid-day sun ; no glare, no flames to be seen, but a golden light pervading the whole of the vast enclosure ; the color of the hair, complexion, and costumes of the workmen perfectly distinct ; under the looms not the slightest trace of shadow. In fact, the result attained was an absolutely perfect ideal light for textile work. The bluish tinge of the arc light itself, when lighting direct, is more apparent than real, because it does not prevent the most delicate shades from being appreciated. If, however, it is considered disagreeable or undesirable, it can be altered, as it was in this particular weaving factory, by mixing a trace of yellow with the ordinary whitewash ; the ceiling is then still white, but the apparently bluish tinge is eliminated.

The result of this visit was the application of four inverted arc lamps in the large low machining room at the writer's works. The darkest portion of the shop was chosen, and the four arc lamps were placed in, approximately, the best positions for lighting a certain area. The ceiling not being plastered, it was considered advisable to nail light scantlings up to the joists, which were afterward whitewashed. These lights have now been running almost day and night for about two years, and with unqualified success. The four arc lamps have replaced twenty-six glow lamps ; but whereas each glow lamp lighted up its own work only and a few inches around, the whole of the area lighted by the four inverted arc lamps is bathed in a gentle temperate light, absolutely equal in all parts. This was encouraging, as an arrangement of this description involves a heavy expenditure, and it was, therefore, considered advisable to have further experience before going more largely into it. Moreover, this plan of lighting would not always be applicable. If the ceiling were very low, it would scarcely be practicable, because the arc lamp must hang a certain distance below the ceiling, and still leave head room. There are also places where the amount of light required is so small that it would be injudicious to go to the expense of applying these lamps, which are capable of so much more duty. It was determined, however, to make an experiment on a practical scale at the author's works, and, with this object, to apply inverted arc lamps for the lighting of a three-story building with large attic floor above.

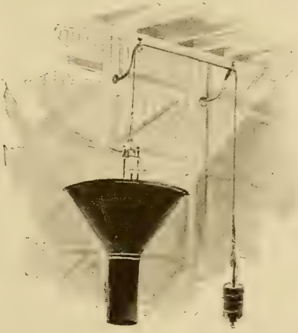
With the object of avoiding any difficulty in the future it would seem advisable, before proceeding with the further development of the plan of inverted arc lighting, to consult the insurance companies in each individual instance. The old style of insurance, where heavy risks were taken by one or two companies only, has now been altered, so that in large works, such as those here considered, the risks are divided among a large number of companies, who, in their turn, sub-insure their risks in other companies not primarily engaged. There is a tacit understanding between the companies that one surveyor may act for the whole of them in any one particular case, thus judiciously securing uniformity of action. But it unfortunately happened that the four lamps in question, which had been tried for some months at the works of the writer's firm, were lent by them, along with a dynamo and driving power, for the purpose of ascertaining how a certain cotton mill, which had the disadvantage that one corner of the bottom room was darkened by buildings outside, could be lighted so as to replace the missing daylight. The four lamps were placed in position and tested. The result was far beyond expectation. It was found that the cleanliness of the work, which is an essential requirement in cotton spinning, could be supervised to a degree hitherto unattainable by artificial light. The owners of the mill were then anxious to adopt this kind of lamp immediately, but they met with an absolute refusal from the insurance companies to allow any open arc lamp to work in a cotton mill. This led to the question of its further use in the iron works of the writer's firm, and at first a blank refusal was received, without any reason being given; but correspondence of some months resulted in permission being at length granted to continue its employment under certain rigid conditions. These, indeed, were reasonable as regards the conducting area of the wires, the voltage, safety fuses, and other necessary precautions.

In order to see whether there could be any valid objection to its use in cotton mills, the author made a fairly complete series of experiments. The danger in cotton mills is supposed to be that the finest fibres or filaments are liable, in the process of spinning, to escape in a certain proportion, under the action of the draught caused by the moving parts; and being of much the same specific gravity as the air, they are easily carried by upward draught. When they reach any ironwork, either columns, beams, shafting, or gas pipes, they have a tendency, owing to the latent electricity always developed in textile fabrics, to attach themselves radially to the electric or magnetic centre; and as the carding-room air in a cotton mill is always more or less charged with these floating filaments, the insurance companies feared the result of combustion by contact with the open arc would be that the fire would be conducted to a dangerous quarter by the loose filaments adhering to wires, etc. This fear is found to be absolutely groundless. Repeated and extended experiments have, in every case, failed to show any indication of danger from such a cause.

The fallacy of the insurance companies' objection is rendered apparent by the fact that at the present time they allow open gas jets in all cotton mills. If there were any danger in an open arc lamp, there would surely be more in open gas jets, which, of course, are more numerous than arc lamps would be. Furthermore, the arc lamps have to be lowered every eight hours of work for the purpose of changing the carbons. The gas jets are turned off when not required, and lighted again when wanted; this may occur two or three times a day. But every time the electric lamp is lowered it is thoroughly well cleaned, which is especially easy, as it consists simply in wiping the wire and the inside of an enameled reflector. To prove that the arc lamps cannot convey fire by contact with the cotton fibre, the author has let fall into the inverted reflector quantities of what is termed cotton fly, being the lightest and most inflammable part of cotton fibre, and as soon as the level of the arc was reached and the top fibres were ignited, the fire spread rapidly round the cone of the reflector and burned downward toward the bottom. When keeping the eye level with the top of the reflector, it was impossible to see anything escape over this level, except the black tinder resulting from the combustion of the fibre or fly. With the true cotton itself, smoldering particles might be seen to the extent of from four to six inches above this level; but it was proved that these smoldering embers had no heat beyond that necessary to give them their color, for they were not even capable of exploding gunpowder.

For the purpose of further elucidating the question of fire risk, the author visited a mill in Belgium, not far from Ghent, where very coarse numbers were spun, the cotton being of short fibre, and the amount of evaporation, as it is termed, of fly from the lower filaments was particularly great, the cotton used being of the poorest quality. Directly over the carding engine was an arc lamp of more than 1200 candlepower, and during four hours spent in watching and noting the effect of the lamp upon the fly, on not one single occasion was the slightest spark visible outside the reflector. Sometimes when the fly was unusually thick in the air, owing to a carding engine being brushed out, a slight corruscation could be perceived near the centre of the reflector, like the twinkling of a star; but this would occur only once, now and then.

Undoubtedly a certain amount of fly was consumed, because when the lamp was lowered for examination a residue was found in the bottom of the cone, composed of the very lightest tinder of cotton, but utterly uninflammable under any circumstances. In England the insurance companies declined to countenance any experiments, on the ground that mill owners had been satisfied up to that time with the ordinary gas light and with their insurance regulations, and therefore they could see no good reason for a revolution of ideas. Furthermore, the definite allegation was made that on two occasions fires had been caused in cotton mills abroad which were lighted by arc lamps. Feeling the importance of ascertaining what amount of truth there was in this statement, the author wrote to the proprietor, manager, and others interested in each instance. In the first it transpired that not a cotton mill, but a cotton store had been burned, which was lighted not by arc lamps, but by glow lamps only, and the theory to account for the conflagration was that of spontaneous combustion, which is by no means rare when cotton is stored in bulk. In the second instance the lighting was not by the open arc lamp inside an inverted conical reflector, but by an ordinary arc lamp surrounded with a glass globe. There was an aperture in the bottom of the lamp, and owing to some disarrangement of the clockwork regulating the carbons, a portion of an incandescent carbon had been split off, and, falling through the aperture upon a mass of cotton beneath, had set it on fire. When cotton in a loose condition does get on fire it is much like a train of gunpowder; and this mill, which was kept in a condition far from clean, being covered with a thickness of fly steeped in oil over the floors, walls, and ceiling, became so suddenly a mass of flame that the workpeople had considerable difficulty in making their exit from the burning building.



THE INVERTED ARC LAMP WITH REFLECTOR.

The complete absence of danger from the arc lamp used by the author will be more thoroughly appreciated from a description of its construction. It consists of two carbons of different diameters, the upper or negative carbon being solid, and the lower or positive carbon being annular and rather larger in diameter. Their areas are 0.200 and 0.486 square inch respectively, which proportion ensures their both consuming at the same speed, thereby avoiding the necessity of any complicated clockwork arrangement to differentiate the speed of the feed. In this lamp, indeed, there is no clockwork, but the carbons are drawn together by a pulley, string, and counterweight, their distance apart being regulated in the usual way by a magnetic brake. The pulley, weight, and brake are all contained in a cylindrical box attached to the underside of the cone of the reflector, and the only interruption to the light above is that occasioned by the thin arms forming the clip which holds the upper carbon. The crater carbon is here the lower one, in order that the larger number of rays produced may be thrown upward. The cone reflector is 25 inches wide at the top and 7 inches at the bottom, the angle of the cone being 88 degrees. The interior surface is ordinary white enamel upon the sheet-iron exterior. Each lamp is balanced by a counterweight over pulleys, and the counterweight hangs conveniently alongside either a wall or a pillar, so that it may not be in the way of traffic. Thus it is easy to lower the lamp for the purpose of renewing spent carbons, which has to be done about every eight hours, and requires not more than one minute per lamp. The plan of inverted arc lighting has now been in use in some portions of the writer's works for twelve and thirteen hours a day during the last twelve months, and sometimes almost night and day; and the result of its working, he has every reason to believe, may be considered successful. The building consists of three stories, each room 123 feet by 55 feet; the bottom room of all is surrounded to such an extent by other buildings that it was necessary to keep the gas burning the whole of the day. The only glow lamps used are those in the attic, or pattern store, most of which are portable for the purpose of finding patterns on the various shelves; and also, strange though it may seem, two glow lamps in the bottom room, for the examination and repair of slightly defective flutes. The latter lamps had to be applied because the reflected light from the arc lamp gives no shadow; and in order to perceive the minute defects in the flute it is necessary to have a light that will give a prolonged shadow, for the purpose of exaggerating what is to be seen.

When first this mode of lighting the rooms was set going and the gas turned off at the mains, there was much grumbling of the workmen, who protested that it was impossible to perform their work by the new light. This difficulty, however, had been foreseen, and they were informed that as the light had been put in at a large expense for their comfort and health, they must at least give it a fair trial. Within six weeks of starting its regular working, something occurred which prevented the requisite steam power from being furnished to the dynamo, and the gas had therefore to be turned on again, exactly as it had been in the former time. The result was a deputation to the manager on the part of the workmen to know what they were to do, as they could not see how to perform their work by gaslight; and on one or two occasions since then, when the light has failed through one cause or another, the workpeople have declined to work with the gas, stating that they preferred to wait until the electric light was on again, and that they could pull up the time lost. The lights are steady and free from flicker; if ever a lamp is seen to flicker it may be certainly concluded that it has not been thoroughly cleaned, and that the carbon slides are sticking in the magnetic brake. There are no dark places on the floor, and underneath the lathes and other machines, and although directly below the reflected light, there is no such thing as a defined shadow.

Four inverted arc lamps were tried by Mr. John A. F. Aspinall in one of the Lancashire and Yorkshire Railway workshops, at Horwich, England, where, however, owing to the great height at which they had to be fixed, they were not successful. They have since been placed in the large drawing offices, and the light for drawing purposes is as perfect a light as can be. Failing, on account of the height of the workshop, to arrive at a satisfactory result with the solely reflected light, Mr. Aspinall has succeeded in lighting the main machine shop with ordinary open arc lamps, each protruding through a whitewashed disc, formed of light boardings framed together. A curious combination is thereby produced of lighting by the reflected and the direct rays. It has not the whole of the advantages of the reflected light, because the eye has a tendency to glance upward toward the dazzling arcs, and shadows are projected. Nevertheless, the writer is convinced that by this combination of reflection a gain has been achieved of at least 25 per cent. over the ordinary direct arc lighting.

The light has proved in practice to fulfill the requirements enumerated at the beginning of this paper as the necessary qualifications of a good artificial light, and for any class of manufacture for which it is applicable. For bleach and dye works, where it is necessary to distinguish minute differences in shades of color, it must be invaluable, permitting this delicate work to be carried on in the dull winter days, which is now difficult, if not impossible.

ANTI-FRICTION MATERIALS.

By Killingworth Hedges, M. Inst. C. E.

THE use of oil as a lubricant in machines is to separate the rubbing parts and to diminish the friction of metal upon metal by an intervening film of the lubricant. If the oil is supplied in sufficient quantity to cause the entire separation of the metals, the friction may be reduced to a measure of the viscidity of the unguent used; where oil is furnished in less quantity, the friction of metal upon metal is usually resistance due to interlocking particles of the revolving and stationary parts, the oil used under this condition finding its way from the bearing, loaded with the metal that is gradually torn from either the revolving shaft or the bearing in which it has worked.

In discussing the subject somewhat over a year ago before the British Association for the Advancement of Science, the author remarked it to be a well-known fact that heavy lubricants effect a better separation of the metals than those that are more limpid, although the power required to slide the surfaces one upon the other is much less with the latter than with the former, but at the same time the wear and tear of the metal may be greater. It has been stated by more than one authority, that it makes little difference what metal is used for the bearing of a revolving shaft, provided oil in sufficient quantity can be introduced, so as to separate the shaft from the bearing in which it revolves. This is proved by the success which attends the use of cast-iron for the bearings of ordinary shafting, it being no unusual occurrence to find the cast-iron sleeve of an adjustable hanger showing the tool marks after running several years with an excess of lubrication. Such a bearing would, however, quickly seize if the oiling were neglected, and therefore the friction may be said to vary according to the attention paid to the oiling. For very low pressures, amounting to only a few pounds on the square inch on the rubbing surfaces, oil causes a loss of power, so as to make it advisable, wherever possible, to dispense with it altogether. Professor Coleman Sellars even goes further than this and states that even when the pressure on the rubbing surfaces is less than 50 pound per square inch, the viscidity of the unguent acts as a sensible retardent.

Engineers have for a long time been looking for a material capable of being used for bearing surfaces and having a low co-efficient of friction when worked dry and without any oil. The idea is not one of recent date only, but may be said to go back to the time of the Romans, as some of the hand flour-mills found at Pompeii have the lower stone fitted with an iron bearing which evidently worked dry in the stone socket of the upper stone. The celebrated Coulomb experimented with an iron axle moving in a bush of elm, the friction being stated to be "$\frac{1}{20}$th of the force of pressure." He also made numerous experiments with wood axles slightly smeared with tallow, and also recommended the use of blacklead. The material which he found to give the best results was green oak on elm, and I believe the wooden axles of wagons which are used in some parts of England at the present time to transport heavy grindstones from the quarries, are constructed with axles of oak in a similar manner. Throughout Egypt, in the Nubian water-wheels, which are everywhere employed for irrigation, unlubricated wooden bearings are used, which appear to wear very slowly, the surface of the bearing acquiring a fine glaze. Stone bearings have also been employed for shafts. According to Rankine, the natural stones fit for this purpose are those which are wholly free from grittiness and are somewhat inferior in hardness to iron, such as gypsum, pure clay slate, compact limestone, marble and silicate of magnesia. From the latter the substance called "adams" was made by calcining the magnesia, grinding and molding it by hydraulic pressure into blocks, which were then baked.

In addition to these oilless bearings there are others in which, perhaps, a small quantity of grease might have been employed, such as the leather bushes used in spinning wheels, and the leather band on that part of the oar which works in the rowlock may be quoted as an instance of leather working on wood. Glass has also been tried, but the only kind which has survived to the present, and has been the most successful of all, is the plumbago bearing. The author has been told by the old millwrights that this material was often used in the footstep bearing of the upright shafts in water mills, and most of us have seen plumbago employed instead of tallow for lubricating wooden bearings, and there is the familiar example of the carpenter's screw. The first adaption of plumbago in a more practical form was the invention of Gordon, who inserted a number of molded plumbago plugs in the standard-size axle-box of an ordinary carriage wheel. It is said that the vehicles ran successfully without any lubricant.

Graphite or plumbago is the principal ingredient in numerous inventions for dry bearings, many of which have not got further than the Patent Office. It has been mixed with pulverized iron, asbestos, vegetable fibre, paper pulp, blood and in one curious instance sponge is used. In nearly all these applications the anti-friction composition is packed into suitable grooves, which are used in the bearing in very much the same way as asbestos is used in cocks. A substance which has been termed "metalline," which, although it contains graphite, appears to be composed of finely divided lead, has been rather extensively employed. The chief disadvantages were the expense due to the way the material was used, in the form of little plugs let into drilled holes, and the necessity for oiling when the plugs were worn sufficiently to cause contact between the metallic surfaces, thereby changing the character of the bearing.

The latest form of dry bearing is of solid material, which can either be molded so as to fit any plummer-block, or can be tooled or worked in the same manner as an ordinary brass. A new material for this kind of bearing, recently tried in the United States, is termed fibre-graphite, and consists of finely ground plumbago, mixed with wood fibre in a moist condition, and pressed into a mold of proper form. It is then saturated with some drying oil and oxidized in hot dry air. This bearing has been favorably reported on by a committee of the Franklin Institute, and a shop has been fitted up complete, so that the whole of the machinery, including the steam engine, runs without any lubrication at all. The report, which may be taken to apply to dry bearings generally, states "that an invention of this kind by diminishing the use of lubricants, diminishes the cost of machine construction by doing away with the many devices incident to oil—oil cups, oil-hole covers, the oil-holes themselves which have to be carefully placed, oil tubes to lead the lubricants to the inaccessible parts of machinery, as well as the cost of the personal attention and the cost of the lubricant required to keep the machinery in perfect order."

My own investigations on a suitable material for an oilless bearing began with the use of plumbago, which was molded so as to form a circular bush, but this was soon discovered to be a failure on account of its rapid wear. I then constructed bearings of ordinary carbon, such as is used in batteries, and for producing the electric light by means of the voltaic arc. The first experiment was made with the bearings of a small dynamo, which ran for a considerable time, but the drawback of using carbon was mainly on account of the impurities which it often contained. A small amount of silica in the carbon was found to cut the shaft very badly, while if soft carbon was used the wear was as rapid as with plumbago. In order to lessen the cutting action and the friction, finely powdered steatite was mixed with the carbon and thenceforth no difficulty was experienced, even when the load was unequally distributed on the bearing. The name of carboid has been given to this mixture, its specific gravity being 1.66, that of carbon, as used in arc lamps, being about 1.68; therefore carboid is about one-fifth the weight of brass. It can be molded with the same ease as carbon, and can be turned, bored, or shaped to any desired form. In practice it is found that the cylinders, as they leave the molds, are quite true enough to be put into bearings without any tooling, although it is preferable to run for a short time with half the load and then remove and scrape the bearing, so as to equalize the surface of contact.

Professor Sellers, writing on the Franklin Institute report, states that "the co-efficient of friction is lower with the dry bearings experimented on than that of many oiled bearings in good condition, and that it is undoubtedly lower than with metal bearings, as usually operated with moderate attention and poor qualities of oil. It seems to be constant in its frictional resistance, whether warm or cold, while it does not run lighter when worn by use, as some oiled bearings do. Its uniform action is better than many oiled bearings and very much safer; the constant amount of frictional resistance being known can be provided for in the power of the machine." The above agrees in the main with Professor Unwin's experimental results with carboid. A bearing 1½ inches in diameter by 2½ inches long, cut in halves, was tested under loads varying from 100 pounds to 1800 pounds, or about 15 pounds to 170 pounds on the square inch, at speeds from 110 to 490 revolutions per minute, the period of test extending over six days, during which the bearing was kept almost constantly running without any lubrication or attention.

Summarizing the experiments, it appears: 1st. That the co-efficient of friction is almost the same and has not diminished as the carboid became worn to a better bearing surface. 2d. That the co-efficient of friction increased as the temperature increased during the run, but is practically the same for any increase of pressure, and diminished with increase of speed, the maximum number of revolutions per minute being 490. 3d. That no injury is causd to the shaft even if the bearing gets very hot, as it was found to be impossible to make it seize.

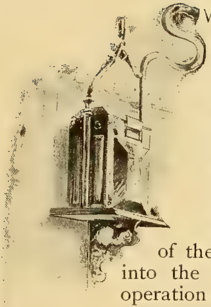
The conclusion arrived at by the author with regard to dry bearings is that the frictional resistance is governed by the conductivity of the shaft and the holder or support of the bearing; if this be so arranged that any heat generated be dispersed, the co-efficient of friction will not exceed that of a lubricated bearing.

If the bearing works under such conditions that any heat, generated at starting a new bearing, may readily be conducted away, the first cost of a dry bearing will be less than any form of brass, but taking the case of a dynamo bearing where any excess heat might be disadvantageous, it will be necessary to carefully true the bearing by scraping so as to fit the shaft, and under certain conditions where there is a great pull on the belt, it may be necessary to keep the bearing cool by means of a circulating flow of water. The economy of working is very marked. Besides, the cost of the lubricants used in large establishments, there is also the attention required to apply the oil and keep the parts clean. In laundries and in those trades where unskilled labor is employed, the danger of oiling machinery in motion is very great; besides this there are instances where the lubricant used is in itself a source of danger, such as the risk of oil waste taking fire by spontaneous combustion, and the drip from bearings certainly renders the floors of the mills highly inflammable.

The principal application of carboid up to the present time has been for the bearings of ordinary shafting, and for bushing loose pulleys. It has also been applied for the bearings of steam heated rolls, such as are used in cloth mills and paper works. The result of two years' experience and many experiments with light trucks seems to point out the desirability of extending its use to the axle-boxes of tramcars, and perhaps railways generally, as it involves no change in the axle-boxes; even the existing brass can remain and be faced with carboid, which can be cemented to either a smooth or rough surface.

ELECTRIC STATION ECONOMICS.

By Professor D. C. Jackson.



SMALL economies in electric station management and operation are things which have a peculiar faculty of swelling up to big totals, a fact of which wide-awake managers with eyes to profitable running have had ample opportunity to satisfy themselves. One of the items entering largely into the question of economical operation is the equipment of station instruments. The term station instruments may be made to cover a variety of tools and indicating devices, from the coal shovel to the main fuse block. The essential electrical instruments are such as will enable station men to handle dynamos and look after their regulation with the greatest precision, but with the expenditure of the least labor and with the least possibility of accident. With the usual construction, the electrical instruments are mounted collectively on a switchboard, but seldom in the best manner. Remember that accidents may involve, first, the operator; second, the plant; third, any branch of the plant.

In discussing the subject recently before the Northwestern Electrical Association, the author took occasion to point out that while safety for careful operators is usually provided, the safety of the plant itself is seldom properly considered. Fires, for example, have been far too frequent and disastrous in their occurrence. A great many of the fires in electric stations start at the switchboard. These can be made almost absolutely safe, and, with proper construction, switchboard fires should be almost unknown. How many stations have properly constructed switchboards? And how many stations pay a fairly low rate of insurance? A saving of 25 cents on insurance rates will pay for considerable improvement in the switchboard. By making the improvements and insisting upon intelligent inspection by the insurance companies, the improved rates can be secured. At the same time a guarantee against fire is obtained.

This is better than insurance, for, however well the insurance companies may treat one after a fire, they will never repay all the losses incurred. Build switchboards of non-combustible material. Marble is not very expensive and is better than slate. If combustible material is used for the board, never make it solid, but arrange it simply as a skeleton upon which the instruments may be secured. Set the switchboard at least two feet (three feet is better) from the wall, and have all the wiring done in the best possible manner and in plain sight. Under no circumstances close the ends of the space back of the board, making it into a sort of rubbish closet. Keep the space all around the board light and clean. Nothing will guarantee neat, safe wiring and safe storage of material except the entire absence from the station of dark corners and closets. There are, by the way, few station hands who will wire a switchboard in a neat and safe manner without excessive expense unless they are carefully directed.

The switchboard should be located conveniently and the instruments conveniently placed thereon. The dynamo instruments should be bunched together, and the different devices belonging to each individual dynamo circuit should be placed in vertical rows. This avoids the probability of the accidents to machinery which are bound to occur when the instruments are irregularly distributed. System at the switchboard is just as important to economy as is system in the accounting methods. Pressure indicators, cutting-in galvanometers, ground detectors and other instruments which are common to all the dynamos should be placed where they are easily seen by a man at the dynamo regulators. Devices placed in the feeder circuits may be placed either above or at one side of the dynamo instruments. In any case, the arrangement should be such that extensions may be readily made.

The number of instruments on the dynamo and feeder circuits should never be multiplied unnecessarily. Their type and number in any case depends upon the type of the apparatus and the purpose for which it is used. Thus arc light plants require an arrangement which differs completely from that which is required in alternating incandescent stations, and the latter differs from that required in stations supplying a continuous-current constant pressure distribution. If arc light dynamos with separate regulators or controllers are used, these should be solidly mounted near the dynamos to which they belong. In each case the maximum of safety and convenience should be sought in the choice and arrangement of the instruments. The arrangement of the standard panel switchboards of two or three prominent manufacturing companies may be followed with profit. Where two or more classes of machinery are used, the different types of dynamos should be set together and the switchboards should be distinct, but side by side.

Let us drop the electrical question now and go over to the steam side. We will start with the coal bin and simply touch upon the instruments or tools not generally used, but which can usually be advantageously added to the equipment—that is, which are likely to add to the dividend-paying capacity of the station. The first instrument on this list is a platform scale for weighing in the coal. Daily records of coal consumed should be carefully kept and compared with records of the electrical output, day by day, week by week, and month by month. Complete daily records enable a station manager to readily determine whether he is getting the results with the least expense. The coal records also enable a direct comparison of the economy of the different grades of coal. Many station managers give too little attention to this matter, simply purchasing the grade of coal which happens to have the lowest price per ton. This is frequently all right, but sometimes it is not economical.

The coal shovel is an instrument which requires a great deal of careful supervision. The coal records and automatic records of steam pressure serve this purpose. An automatic steam pressure recorder is not an expensive instrument. If one is properly installed and its indications are acted upon by the manager, it will soon save its cost. There are various automatic recorders. A first-rate one is the Bristol. The Edson, which is more expensive, has some advantages, which are, however, of little moment in a small plant. Those who have operated stations, both where pressure recorders are and are not used, will doubtless be ready to bear witness to their advantages. Thermometers in the feed water pipe and in the steam pipe are not essential to the operation of a station, but they are certainly advantageous. A throttling calorimeter made of ordinary fittings is also serviceable. The use of the thermometers and calorimeter may look like kid-glove engineering, but if one is anxious to get the best result from a steam plant for the least cost, they should be employed. They are not kid-glove affairs, but good common-sense appliances. Steam gauges on the boilers (good, reliable ones), all will agree, are essential, but it is not usual to put one in the steam pipe near the engine. It is a good idea, however.

I am acquainted with a plant of considerable size which operates twenty-four hours a day. During daylight the load on the plant is small and in such cases it is the impulse of the average fireman and engineman to throttle the steam by partially closing the boiler valve. In the station I speak of the reduction in the pressure is twenty pounds. Let us see the result. In first bringing the boiler pressure up to 100 pounds above the atmosphere a certain amount of heat is furnished to the steam from the fuel. Where the pressure is reduced by throttling, the steam is cooled to a lower temperature and some of the heat contained in the high pressure steam is lost. This loss means an equal decrease in the power of the steam, and, therefore, the coal which was used in raising the pressure from the low figure to the high one is simply thrown away. When it is necessary on account of light day loads, it is much more economical to lower the boiler pressure to a satisfactory figure. In the station referred to the loss in fuel on account of throttling was from 5 to 10 per cent. Five to ten per cent. of the fuel used on day load makes a considerable item in the period of a year, which will pay for the recording boiler gauge and a gauge in the engine pipe, besides adding a sum to the dividend account. It is true that the gauge in the engine pipe does not remove the fireman's impulse to reduce pressure by throttling, but if his work is constantly under inspection the impulse is much less likely to be irresistible. In this connection let me remark regarding the usual practice of cutting off the condenser at times of light load when condensing engines are used. Under such circumstances fuel is saved by keeping the condensers running, but reducing the boiler pressure to hold the engine cut-off at an economical point.

Another instrument of much value is the engine indicator. This is particularly useful in determining whether the engines are working at their most economical cut-off and whether the valves are properly set. A great many engineers tinker with their engine valves, and rely upon their eye and ear to set them properly. This is generally poor economy, and the indicators should be brought into requisition. If cards are taken at fixed intervals and filed for reference they may be made a decided aid in the effort to keep everything at the most economical point. In the valve setting alone, if the indicator can point out the way of saving a very small per cent. of fuel, it will quickly pay for itself in this country of expensive coal. The horse-power calculated from the diagrams, compared with water and fuel records, and again with electrical records, give all the elements necessary for determining at any time whether the plant is doing its duty satisfactorily.

I have spoken particularly of instruments that are frequently not used in the stations, but which can be made of much valuable assistance in reducing expenses. These are not varnished, theoretical ideas, but hard, common-sense, dividend-earning suggestions. They can be put into service without increasing the operating costs in any way, and the instruments will ordinarily quickly pay for themselves.

THE INFLUENCE OF ELECTRICAL INVENTIONS.

By Thos. D. Lockwood, M. Am. Inst. El. Engrs.

HOW much of present progress in the arts and sciences we owe to the influence of electrical inventions was detailed at some length by the author in a paper read before the late Congress on Patents at Chicago. Briefly recurring to the subject here, it is interesting to recall that prior to the time of Queen Elizabeth, the only useful and scientific application of electricity and magnetism was that of the latter science in the mariner's compass. The influence of this invention on the world's history is not to be lightly esteemed, and without it we cannot believe that Vasco de Gama would have essayed to double the stormy cape in his desire to achieve the sea route to India, or that Christopher Colon would have dared to steer due west on his voyage to the far East. Humanly speaking, therefore, we may believe that without the knowledge of the magnetic compass the discovery of America by civilized Europeans would have been delayed for many years.

For the two centuries or more which elapsed between the year 1600, A. D., when a great man, William Gilbert, the court physician of Queen Elizabeth, triumphantly proved that the only road to electric knowledge was the rugged one of electrical experiment, and 1831, when Faraday showed the complete correlation of electricity and magnetism, the record of electrical progress constitutes not a record of invention, but a record of discovery of principles and of application of principles, each discovery brought about, clearly, by the influence of those previously made, and each, in turn, aiding materially in the evolution of the next. The main influence exerted by electrical discovery and invention up to the end of the first quarter of the nineteenth century, was that of promoting further discovery. And this was in the highest degree necessary, because, not until a practical knowledge of the principles under which the forces of electricity and magnetism operate was acquired could it become possible to intelligently apply these principles.

The art of electro-metallurgy in its two great departments of electrotyping and electro-plating is probably the earliest important application of electrical science, and has been the foundation of a long list of patented and unpatented inventions. Its influence, however, has not been restricted to the promotion of invention, although even there it has not been idle. New and improved solutions of metal salts, improved forms of galvanic batteries, forms of magnetic and dynamo machines and arrangements of electric wires, all in some way especially adapted to electrolytic or electro-metallurgical purposes, have formed the subject of a host of inventions in this branch of work. In facilitating the production of publications and pictures, we owe much to electrotyping; and the influence of electro-plating in the dissemination of a love for the beautiful, and in the cultivation of correct taste among the people by the reproduction at low cost of articles otherwise unattainable, is too great to be overestimated.

Electric telegraphy is not yet sixty years old, but "its lines are gone out into all the earth." It has grown out of the combined application of some three or four discoveries. In England, Messrs. Cooke and Wheatstone together devised a visual telegraph, while in the United States, Morse, availing himself of the powers of the electro-magnet, devised a similar alphabet, forming a permanent record which could subsequently be read off. It was soon found, however, that the sounds made by Morse's recorder in doing its work could be interpreted by the ear, and receiving messages by sound is now a practice well nigh universal.

Who can calculate the influence which this one invention of the telegraph has, and is yet to have, on the destinies of man? The many varieties of printing, writing and other telegraphs, the phantom wire of the duplex and the quadruplex, the gutta-percha covering, rendering ocean telegraphy possible, the new trades and professions, furnishing honest and remunerative employment for thousands of persons, which are necessary for the manufacture of wires, cables, instruments, and for their proper construction, maintenance, operation and repairs, are other examples of the far-reaching, widely-extended collateral influences of the telegraph.

Consider what the morning paper would be and would not be without its telegraphic news. We should, instead of composing a great and cosmopolitan nation be restricted in our interests, and bigotedly sectional, to an extreme of which we cannot form any conception. The telegraph has revolutionized the business methods of the commercial world; it has civilized the business methods of the diplomatic and national world; it has done more to realize and embody that "one touch of nature which makes the whole world kin" than has, to the present time, any other one product of the century of applied electricity.

Though the telephone will to the succeeding generation be as familiar a household word as the locomotive, the steamship, or the photographic camera is to us, yet before the Centennial year, 1876, there was not a single speaking telephone in the hands of the public throughout the wide world. What has been and is the influence of the telephone? I think that to this invention we must attribute the universal renaissance of experimentation which has found fruition in all of the electrical victories of the years subsequent to its introduction; for it afforded in itself indisputable evidence that, up to that time, inventors had but dabbled in the shorewaters of that illimitable ocean of possibilities of electrical utilization, and, at the same time, it encouraged the hope which springs eternal in the inventive breast—the hope of reward. And around the telephone sprang up naturally an innumerable host of other inventions, representing improvement, expansion, subsidiary appliances, conductors, disturbance quellers and telephone exchange apparatus.

It is inevitable that the mass of inventions must represent change without improvement, but it may be that even this fact is not wholly without good, in that possibly the thought to which the producers of this class of invention have been stimulated is an elevation of mental effort, proportionately as great as that exerted in higher spheres by a Watt, a Fulton, or a Whitney, and is therefore an illustration of the tendency of the influence of invention to raise the mental plane of the race at large.

Benjamin Butterworth, United States Commissioner of Patents in 1884, said: "On the seventh of March, 1876, less than nine years ago, the first patent on the telephone was granted. Prior to that date it was unknown in the field of invention. Since that time there have been issued over 1000 American and over 500 foreign patents, directly traceable to the parent invention." From the date of grant of the above-mentioned "first patent on the telephone," to the date of its expiration, seventeen years later, there were granted in the United States seven hundred and seventy patents relating to telephones, and no less than twenty-one hundred and ten patents to telephone appliances. Prior to March, 1876, there were no speaking telephones in use anywhere; there was not a single yard of telephone wire in use; there were no underground conductors, no telephone exchanges and no persons employed in telephonic work. But an examination of the instructive statistical diagrams found in the exhibit made by the American Bell Telephone Company at the World's Fair indicates that at the beginning of 1893 there were in use in the United States alone, in round numbers, 440,800 miles of telephone wire, of which 91,500 miles were underground; 552,700 telephones and 1350 telephone exchanges; that connected with these exchanges there were over 232,000 subscribers; that the number of connections between the lines of these subscribers in a year reaches 600,000,000; and that the telephone exchanges provided employment for 10,000 persons. These facts speak for themselves and depict more eloquently than could any amount of additional statement, the immense influence exerted by "the still, small voice" on society, business and the people at large. Consider the time saved to each of those 232,000 persons by the 2500 conversations forming his share of the 600,000,000!

Let us think of the habits of concise expression to which the public is educated by the quiet ministrations of the telephone. Let us ponder on the fact that it is possible to call a director's meeting in Chicago, in which some of the directors present are in New York and others in Boston, and to transmit the business of the hour in such a meeting with facility and despatch, or on the enormous amount of travel with the consequent loss of time saved by the existence and availability of the telephone. The side influence of this wonder-working invention is not less important; its use in mines and by the submarine diver; its influence in physic and surgery, and as an instrument of philosophical research; in telegraphy without wires and in scientific measurement. How great is that influence, considering the youth of the invention! How infinitely small, measuring the future by the light of the geometrical progression of rate of progress of the past!

Electrical illumination in its two great departments of arc and incandescent lighting must not be overlooked. It was made practical by the evolution of the dynamo from Faraday's discovery that it was possible to produce electricity from a magnet. For a long time it seemed as though arc lighting were the more important of the two, but with improvement in plant, apparatus and methods, lighting by incandescence is now by far the greater consequence. The power of invention to influence invention is as markedly recognizable in this field as in others. Improved arc lamps have called forth improved dynamos, and the evolution of series lighting on an extensive scale has developed large machines and devices for the regulation of current. The use of such heavy currents as are required in lighting has necessitated the contrivances of many new forms of measurement apparatus and switches.

A similar line of evolution has contemporaneously taken place in incandescent lighting, and an additional field has been developed, making long distance lighting commercially possible by enabling the use of small main line wire over which currents of small strength, but high pressure, are transmitted and transformed at the place of utilization, by means of peculiarly made induction coils, known as transformers, to currents of the requisite character.

Electric illumination, directly and indirectly, has furnished work for many more persons even than telephony, and this largely because light is a thing which all must have, while, up to the present time at least, the telegraph and telephone have been, in a degree, luxuries. Even as late as 1878 there was practically no commercial electric lighting; but there is at the preset time scarcely a town so small that it is not illuminated by electricity. The electric lighting of steamboats has eliminated the dark stateroom. Electric lighting of trains is done in England, has been tried in the United States, and will soon be done again permanently. Churches, theatres and assembly halls are now extensively and most conveniently lighted by electricity, and the electrical illumination of the residence, with its "by-products" of clean ceilings, uninjured book-bindings and unvitiated air is on the rapid increase. The public has become educated to regard brilliantly lighted space as a necessity, so that every one now emulates Goethe in his last call for "more light."

In so many different directions has electrical invention been prosecuted that it is an impossibility even to name them, and metal working, heating and cooking are all pressing themselves daily on our attention. It is, however, impossible to avoid the mention of the employment of electricity as an agent in the transmission of power, and this regardless of whether it is employed to supersede the stationary engine or the locomotive. In the influence which the electric railway exerts on our streets the good preponderates. The streets by its advent are kept cleaner than in the past; the room required is nearly all saved for the passenger, instead of being half occupied by the horse; we obtain greater speed than theretofore, and have a motor more easily controlled than the cable.

Electric power is also cheaper than horse-power. But, alas, with all these we have an adverse influence in the necessarily bare and unprotected trolley wire, in the spider's web of trolley and feed wires, guard wires, guide wires and guy wires, hung over the middle of the street; and withal from time to time the speedy electric car claims a victim from the human race. But electricity is still young, and we hope for great improvements yet by which these objectionable features may be obliterated.

LEADING AMERICAN ENGINEERS.—J. C. HENDERSON.

JOHN C. HENDERSON's portrait, which appears in this number, will be recognized at once by a host of friends and acquaintances, being an admirable life-like reproduction from a recent photograph. For many years Mr. Henderson has been well known to the mechanical and electrical engineering fraternities, to the latter perhaps best through his connection with the Edison interests and, until quite recently, with the General Electric Company as its chief engineer, in which capacity he designed, among other machinery, the vertical, triple-expansion, condensing engine shown by the Company at the World's Fair at Chicago. He was born at Edinburgh, Scotland, coming from a family of engineers and architects, a circumstance to which the early development of his engineering instincts was probably due in no small measure. Inclining more particularly to mechanical engineering, he was entered, while still quite young, as an articled pupil with Messrs. C. D. Younge & Co., of St. Leonards, a firm of engineers and contractors largely interested in the building of not only docks and bridges, but engines, mills and mill machinery as well. Subsequently he became engaged in ship building and marine engineering, spending some time in South Africa in the fitting up of vessels and the building of the line of the Cape Town and Wellington railroad. After a varied engineering experience in Australia, China and India, he became one of the government engineers of the United States of Colombia, in South America, where he spent some time, finally reaching San Francisco in the employ of the Pacific Mail Steamship Company. At San Francisco he designed and erected the first new sugar houses on the Pacific Coast, subsequently again practicing marine engineering in various capacities. Mr. Henderson was also actively interested in the introduction of liquid fuel for steam raising, both in stationary and marine boilers and patented a number of burners for that purpose. He was, moreover, the first to puddle iron with petroleum at the Trenton (N. J.) works of Cooper, Hewitt & Co. For many years he was connected with the Edison interests, and as far back as 1879 he installed the first incandescent electric lighting plant in commercial existence on the steamship Columbia of the Oregon Railway and Navigation Company, which is still in operation. From 1889 until early this year he acted in the capacity of chief engineer of the Edison and General Electric Companies, carrying out much work of interest and value to the profession, also devoting himself to the subject of gas engines and their application to general power requirements. At present Mr. Henderson is practicing as consulting engineer at New York.

Letters to the Editor.

EXPERIMENTS WITH MECHANICAL POWER ON THE ERIE CANAL.

THE recent "experiments" with electricity on the western portion of the Erie Canal, about which the daily papers made such a great fuss at the time and which were used as an additional argument to demonstrate that the time is rapidly drawing nigh when old King Steam is to be dethroned, would be extremely humorous, were it not for their tendency to mislead the laymen and open the door for the perpetration of enormous fraud. It is with the hope of counteracting some of these evil tendencies by reviewing what has already been done, and questioning proposed new departures in the future that this is written.

Take, if you please, as a sample of the stuff that is published and which has a tendency to form public opinion the following flowery extract from a leading editorial from one of the great New York dailies under date of Jan. 21, 1894:

> "The laws of nature have been lassoed, tamed and broken to harness. The resources of steam which our grandfathers explored, which made them feel that they had stumbled on a series of miracles, and which changed the complexion of the world's commerce, forcing our white winged fleet of sailing vessels to come to anchor and give way to the magician who hid himself in the bunker of anthracite coal—these resources are well nigh exhausted. The winds as a propelling power have become obsolete, have taken their place among the genii, the myths, the superstitions of the past. Steam is striking its tents and will soon fall into innocuous desuetude. Our needs have grown so pressing that it can no longer supply them. During the next fifty years it will become a reminiscence. The electric spark is to be the working energy of the twentieth century. It has just crossed our threshold with letters of introduction from students of scientific prestidigitation and we have only had time to look at its face and its stature and to note its aggressive bearing; but it would not be strange if it were to achieve wonders which our children's children will regard with awe and admiration"

While engineers can heartily endorse the first portion of this article and may be excused if they feel somewhat elated over their share in bringing these possibilities about, yet when it comes to "steam striking its tents and falling into innocuous desuetude," or becoming a "reminiscence," we beg to be excused from taking stock in any such statements. We know the child often grows to outrank its father, but how can the child be born without a father, and, as applied electricity depends upon steam for its existence, it is quite evident that steam will not be relegated to a back seat in the immediate future unless we have revealed to us some way of producing electricity from nature without the aid of the steam engine. The average engineer is a very matter-of-fact fellow, wants to be able to weigh and measure all the factors that enter in any problem, is quite convinced that, no matter what his muscular abilities, he cannot lift himself over a fence by his boot straps, and therefore is not likely to go astray on these fallacies; but recent experience with the Keely motor and other kindred devices, show how easy it is for promoters (?) to twist statements of even prominent engineers into seeming endorsements of schemes that are sprung on a confiding public to capture their dollars. As one of these schemes that seem to be in process of development at the present time is the use of electricity to propel boats on the Erie canal, it may prove interesting and profitable to inquire as to what has been done in the past, and what it is proposed to do in the future, to reduce the cost of conveying freight through this great waterway, which has been such a potent factor in making New York city the great metropolis of the Western world, and the State of New York the Empire State of the Union.

At this point it may be permissible to digress a little and state that during the year 1879, Horatio Seymour, Jr., then State Engineer and Surveyor of the State of New York, determined to ascertain positively what foundaton there was for the frequent complaints of the canal boatmen, to the effect that the canals were being allowed to gradually fill up and that other abuses were allowed to exist, which seemed to point to a conspiracy on the part of great rival corporations to drive the canal boatmen out of business. In order the better to understand the difficulties complained of, Mr. Seymour determined, with his assistants and the writer, who was specially engaged for the purpose, to make a personal investigation through the entire length of the Erie Canal and thence down the Hudson River to the dock at New York, and it is due to this fact that the writer first learned of the importance of the Erie Canal in State and National affairs. Without going into the details of how the great corporations, who are in competition with "the barefooted boy and his team of mules on the tow path," have used both political parties in their efforts to destroy their competitor, it may interest many to review some of the more recent efforts made to utilize mechanical power for the propulsion of boats on the canals.

The legislature of the State of New on the 28th day of April, 1871, passed "An act to foster and develop the internal commerce of the State, etc.," and a commission composed of George B. McClelland, Horatio Seymour, Erastus S. Prosser, David Dows, George Geddes, Van R. Richmond, Willis S. Nelson, George W. Chapman, William W. Wright and John D. Foy, were appointed to "practically test and examine inventions, or any and all devices which might be submitted to them, for propelling boats upon the canal by any other motor than animal power." The Hon. Horatio Seymour declining to serve, the Governor appointed Daniel Crouse of Utica to fill the vacancy. This commission was organized by the election of Van R. Richmond as chairman, with Henry A. Petrie as secretary, and a "civil and mechanical engineer," who shall be nameless in this article, so that comparisons may not be odious, was appointed to aid the commission in making examinations and practical tests provided for in the act. In reading up the reports of the practical tests (!) submitted to the legislature in 1872, 1873 and 1874, the engineer of the present day may get an object lesson that is instructive and that may provoke at least a smile, but which we must notice in passing, as we will refer to it again later on to point a moral if not to adorn a tale.

Take, for instance, the case of one of the boats, fitted with a 12 x 12-inch cylinder. One of the reports referred to above says: "The average steam pressure was 68.9 pounds; revolutions of the screw, 89.4 per minute; horse-power, 38.6." It would be interesting to know how the engineer of the commission got this result for a single boat, when accurate tests, made some five years later with the aid of instruments specially designed for the purpose, showed that to propel two boats at nearly the same speed through the current took less than ten horse-power. Some idea of how this 38.6 horse-power result was arrived at may be obtained by reading further from the report, which goes on to say:—"The data from which the former has been estimated, were determined by observations taken at intervals of 15 minutes for the entire run of 16 miles, and are therefore reliable, but in regard to the coal consumption I am not so certain. Having ascertained the weight of a bucket of coal, the engineer was requested to report the number of buckets expended and the statement above is based on his report." Only think of it! Here was the State, purposing to expend hundreds of thousands of dollars, with men appointed and paid to get accurate results, which are finally largely based on a report made by the poor fellow down in the stoke-hole.

Or take, if you please, the case of another boat fitted with compound cylinders of 7-inch and 12-inch diameters, respectively, and with a stroke of piston of 12 inches. The report goes on to state in reference to this practical test:

Steam, high pressure cylinder.	74	pounds
Steam, low pressure cylinder.	18.75	"
Vacuum	15	inches
Revolutions per minute	115	
Cut-off in each cylinder	¾	

With this data, an approximate estimate of the power is made thus:

Speed of pistons, feet per minute...	230.00
Area of high pressure piston, square inches..........................	38.48
Area of low pressure piston, square inches..........................	113.09
Mean pressure, per cent of initial...	96.00
Mean pressure on high pressure piston, per square inch, pounds (72 + 14.7) 0.96 = ...	83.23
Deduct back pressure (18.74 + 14.7).	33.45
Mean effective pressure on high pressure piston, pounds per square inch..........................	49.78
Mean pressure on low pressure piston, pounds per square inch (18.75 + 14.7) 0.96 = ...	32.11
Deduct back pressure, half atmosphere..........................	7.35
Mean effective pressure on low pressure piston, pounds per square inch	24,76
Total mean effective pressure on high pressure piston, pounds (38.48 x 49.78) = ...	1,915.53
Total mean effective pressure on low pressure piston, pounds (113.09 x 24.76) = ...	2,800.11

Therefore,

$$\text{H. P.} = \frac{(1{,}915.53 + 2{,}800.11) \times 230}{33{,}000} = 32.87$$

The principal reason for presenting these extracts from the report of the engineer of the commission is that they may be compared with the data obtained on Mr. Seymour's test, which was made with two boats of the ordinary model, such as are in common use on the canals, except that one was fitted with engines, boiler, etc., and pushed its consort ahead of it. The engine of the "steamer" was of the simple vertical pattern, of 12 inches diameter and 16 inches stroke, plain slide valves, with adjustable cut-off, to be worked from the pilot house. The engine was condensing and all water of condensation was returned to the boiler as fast as made, by a small plunger pump, worked from the crosshead of the air-pump. The propeller wheel was of peculiar design. A hub 4 feet in diameter had four blades, each 2 feet long, bolted to it, thus making the diameter of the wheel 8 feet, with a pitch of 6 feet. The wheel was located astern, after the usual method. The upright tubular boiler, of ample capacity, fitted with internal magazine, would hold 700 pounds of coal. The magazine was charged from the deck, where the coal bunkers were also conveniently located. Artificial draft was produced by a blower driven direct from the crank-shaft. The general design of the entire plant was admirable, the only defect being in the proportion of its various parts.

The principal instruments used during the test were a steam engine indicator, attached to the steam cylinder by short direct connections. A revolution counter was fitted direct to the reducing motion of the indicator. The steam and vacuum gauges were tested by the indicator and variations were noted. To the side of the forward boat a tachometer was secured by a convenient frame of angle iron, and its revolutions were recorded on deck by electricity. Everything being ready, the steamer was loaded with 7300 bushels of wheat, while her consort was loaded with 7800 bushels, so that the united cargoes were 15,100 bushels of wheat, or about 430 tons. The start from Buffalo was made at 1.35 P. M.

July 11, 1879, but owing to detentions, caused principally by low water in the canal through the middle and eastern divisions, the boats did not reach Pier 8, East River, New York City, until 8.40 P. M. on July 21. The following extracts from the data obtained will show the amount and cost in full of the power exerted :

FROM BUFFALO TO ALBANY.

Distance	352	miles
Time	197.5	hours
Mean effective area of piston	111.42	inches
Average revolutions per minute	45.2	
Mean effective pressure at 45.2 revolutions	22	pounds
Piston at 45.2 revolutions.	120.5	feet
Total coal burned	12,950	pounds
Total ashes made	1807	"
Per cent. of ashes	13.95	
Coal burned per hour	65.5	"
Coal burned per indicated H. P.	7.31	"
Combustible per indicated H. P.	6.3	"
Average indicated H. P.	8.95	
Average miles run per hour	1.78	
Average boiler pressure	67	pounds
Coal burned per hour	33.95	

Owing to low water in the canal, as already mentioned, at the time this test was being made, the boats were frequently aground and much time was lost and fuel burned in efforts to get them free. All this militated against the average speed and duty, as given above. In addition, the cut-off was inoperative for less than three-quarters stroke, a defect that was not discovered until too late to remedy it before starting on the trip. This, with other defects, caused a useless consumption of coal, estimated at 3521 pounds, during the trip, and these corrections should be made in order that we may arrive at the actual amount of coal expended in useful work when we compare the cost of propelling with steam as against electricity. The run from Albany to New York, a distance of 143 miles, was as follows :

Time	48.6	hours
Average revolutions per minute	59.2	
Mean effective pressure, at 59.2 revolutions	29	pounds
Total coal burned	4655	pounds
Coal burned per hour	95.7	"
Ashes made	655	"
Coal burned per indicated H. P.	6.2	"
Combustible per indicated H. P.	5.34	"
Coal burned per mile	32.55	"
Average boiler pressure	65	"
Per cent. of ashes	14.07	
Average indicated H. P.	15.4	
Average miles run per hour.	2.49	
Piston speed, at 59.2 rev.	157.8	feet.

It should be borne in mind that the main object of Mr. Seymour's test was to determine with some degree of accuracy what, if any, variations in power would be required to drive the boats through different depths of water, and it became so evident that the less the depth of water, within certain limits, the greater the power required, that in his annual report to the State legislature in 1880 he strongly urged as an improvement that would give the best returns for the least expenditure of money, that certain portions of the Erie Canal, having the least depth of water, should be bottomed out, *i. e.*, a certain amount of earth taken from the bottom and placed on the bank, and the locks lengthened sufficiently to lock two boats at one time. This work is now in progress. There is so much to be said on this subject and the field is so wide for the display of mechanical talent, that justice cannot be done the subject here. But now, having reviewed some of the efforts put forth in the past to utilize steam on the canal, and having shown to those who have the faculty to read between the lines why it is that steam has not been more generally adopted, we turn to this wonder of the nineteenth century, electricity, and ask what has been done to justify the claim that our faithful old servant, steam, is to "soon fall into innocuous desuetude," even where it has been so badly handicapped as on the canal.

We believe it is a fact that a wire was strung along the canal for a short distance ; that a motor was attached to the propeller shaft of a boat ; that the Governor of the State was present among others at a given time ; that the current was turned on and the propeller revolved; that the boat moved in the water; that a great shout was sent up; and then the invited guests went below or ashore and took something. As far as could be learned no attempt was made to determine the cost of moving a given tonnage a given distance in a given time, or, in fact, to secure any data that would enable an engineer to make computations on a commercial basis. There never was any question among engineers that an electric motor could be made to turn a propeller shaft, and as this is about all that the demonstration amounted to, we are at a loss to know what it all means, and are prompted to look for the African in the wood pile.

Knowing as we do of the many efforts put forth by rival institutions to destroy the usefulness of the Erie Canal, may we not be justified in asking if this is a scheme to cumber the tow-path with poles and wires and thus disturb the horse boatmen? Or is it some scheme of the "blind pool" order? Suppose that by experiments, yet to be made, it is demonstrated that boats can be conveyed from Buffalo to Albany by the aid of a trolley along the canal at a less cost to the boat owners than by animal power. Of what advantage is it? How is the boat to be moved when it gets from under the influence of the wire? Until some definite data is obtained or some plan outlined it may be premature to speculate about the matter, but this is a good time to warn every friend of the State's great waterways to keep a sharp lookout for the developments of the coming season.

W. H. ODELL, M. Am. Soc. M. E.

AN ENGINEER'S VIEW OF THE MONEY QUESTION.

I HAVE been much interested in the article entitled "An Engineer's View of the Money Question," by A. F. Nagle, in the December issue, and while his idea is, in the main, just and clear, it seems to me that he falls into an error which would be curious if not so prevalent. That error is in the use of *value*, as a term to express certain conditions prevalent in the matter under investigation. I think that a very large part of the loose thinking and looser talking upon financial affairs is due to obscurity of thought on this matter of *value*.

There is, no doubt, a prevailing idea among the masses of the people that somehow the value of money is arbitrarily established by the government, and that, for their own aggrandizement, those who wield what is known in a shadowy way as the money power, persuade or compel the government to put up the value, and thereby oppress the people. These notions are intensified by politicians, some of whom know no better and all of whom want to secure personal benefit out of them. Hence the existence of Flat money parties and Silver parties. Mr. Nagle says "gold obtains its value in exactly the same manner as all other metals do, namely, through the laws of trade. All that governments do is to stamp the metal and call it by certain names, as guarantees of its being of a certain weight and purity, or 'fineness.'" This is exactly right, except that it would have been better if the *modus* of the "laws of trade" had been indicated. The value of gold, commercially, is determined under the laws of trade by considerations of demand and cost of production. Cost of production alone cannot determine value, because if nobody wants to use the product it has no value, whatever may have been the cost of production. Mr. Nagle goes on to say "there comes in, however, this peculiar result, namely, that the moment a certain weight of gold is made the standard of value, its value cannot change any longer, as it did when it was a commodity." This to my mind is entirely erroneous, and is exactly in line with the fundamental errors alluded to at the commencement. The value of the stamped metal is fluctuating, just the same as the value of the bullion or the ore. The mischief comes out of wrong notions as to what value is. 1, It refers to the esteem in which a thing is held for its utility as applied to persons or things; 2, to the amount of other commodities (commonly represented by money), for which a thing can be exchanged, and so on, through a considerable number of senses or meanings for which the word may stand.

It will be conceded if the word be used, it cannot be, at the same time, employed in all the senses or meanings of which it is capable, and therefore it must be understood in the sense appropriate to the connection or context. To illustrate, the value of gold as an agent to cure alcoholism is quite distinct from its value as a covering for other substances to prevent corrosion, and the value of its use as a remedy cannot be expressed commercially, or in dollars. The value of gold as a covering for other substances to prevent corrosion, may possibly be expressed in dollars, but only in a remote and roundabout way, and as a matter of fact, is not so expressed, nor do men ever attempt to so express it. It is equally impossible to express dollars in terms of suffering or sentiment. Hence, when "value" is spoken of with reference to money it must be considered with reference to commerce, or the use of money as a means for transferring ownership of commercial articles.

The government refines gold to a definite standard, makes it up into parcels of a definite weight, and stamps it so as to impart a government guarantee as to fineness and weight. The established unit is called one dollar, and the only meaning the term has is, that the dollar contains 25.80 grains of gold 9-10 fine. As to the value of that gold, compared with other commercial things, the government has not and cannot have anything to do with it. No fact is more familiar than that, and it is astonishing that there should be in the mind of anybody a confusion about it. The value of a dollar is always measured against the value of the other thing for which it is to be, or may be, exchanged, and in commerce is never judged in any other way. A dollar, or 25.80 grains of gold, is worth so many pounds of coffee one day and so many other pounds the next day. We say coffee goes up or goes down in value, but that is merely a convenient custom; as a matter of fact the value of gold as compared with coffee goes down or up in the same ratio.

I go to my grocer and say to him, How do you value 25.80 grains of gold in terms of sugar? He may reply that 25.80 grains of gold are worth eighteen pounds of sugar this morning, and that I had better trade to-day, for to-morrow it may be lower and I shall only be able to get sixteen pounds. These would not be the words we would use, but they express the transaction exactly. It is the same with every other transaction in which money is employed. Looked at from this point of view, money, of whatever kind, never ceases to be a commodity, and commercial transactions never depart from the familiar principles of barter. The farmer's wife comes into town and exchanges her butter and eggs for tea, sugar, coffee and meal. There is no doubt whatever that that is a commercial transaction, yet no money has passed. The butter and eggs are measured in terms of tea, sugar, coffee and meal. The grocer barters the same butter and eggs to his customer, measuring them in terms of gold. This is a transaction not different in any element from the former. The grocer would barter away the same butter and eggs for any product of the customer's farm as readily as for gold, all that he would require being that the thing bartered for would be salable. But gold is a commodity for which a purchaser can be found at any moment; hence, no one hesitates to receive it. The grocery man might decline to barter his tea, etc., for corn or hay, because he might not have suitable places in which to keep it, or facility for selling it, but he will not refuse gold, because he has a place to keep it in, and he knows that he can exchange it for anything he wants.

The Government is powerless to fix any value for commodities and is, therefore, powerless to fix value to the gold it coins, and it is equally powerless to compel anyone to receive it in trade. It can only say, that if you trade away goods, agreeing to take dollars in exchange, you cannot demand something else in settlement. That is the limitation of legal tender. The Government designates that 25.80 grains of gold, 9-10 fine, shall be called a dollar and every contract calling for dollars shall be settled on that basis. It seems manifest that there cannot be two standards of value. The suggestion of two standard, is as incomprehensible as the fourth dimension, and it is equally easy to talk about it. If the gold dollar is the unit of value, as it has been in this country since 1873, then paper, silver, nickel and copper simply have a representative quality, for which they stand, and represent gold because the Government offers to exchange any of them for gold on demand. Deprived of this representative quality each would stand as a commodity on its own basis, and people in commerce would immediately fix the values separately. This they have repeatedly done in this country. The old continental paper money continued to pass on a par with coin until the people began to distrust the ability of the Government to redeem it in coin. From that moment the value steadily declined as this distrust increased, and when it was certain that the Government would not redeem it, all value ceased.

During our late war, when greenbacks were not redeemable in coin, their value as purchasing agents declined in proportion to public distrust of ultimate redemption, while the value of gold as a purchasing agent did not materially change. When, however, the public began to feel assurance that the Government would be able to redeem in coin, the value as a purchasing agent again arose.

In the selection of a material for money, the prime requisites are a recognized intrinsic value, *i. e.*, a commercial value, and an agreement among the users of money as to the material to be selected. All other questions are of secondary importance.

The recognized commercial or intrinsic value is necessary, because Government is powerless to establish any fictitious value. The agreement on a material is necessary to relieve commerce from the embarrassments of transposing standards. In deciding these two questions a variety of conditions have been considered, such as, uniformity in value, weight, incorrodability, ductility, durability, etc., and the solution arrived at has resulted from the accumulated experience of centuries, covering in its range, a great variety of materials. Aside from the convenience which comes from the use of the best material for the purpose, all things considered, it really makes no difference what material is selected so long as all agree to it. Wampum served every purpose of money until its production became so easy that its intrinsic or bullion value fell so low that it became too bulky for convenient use. Then the people simply declined to accept it as money and it disappeared. Silver would serve every purpose, but even at a bullion value of a dollar an ounce it is too bulky for convenient use in transactions of magnitude. This is a matter of common knowledge. At seventy-five cents an ounce, the difficulty is enhanced. There are many persons living who can remember the disadvantages of want of agreement in the days of the State banks, when no money except coin would pass current, away from the locality of issue, and such persons will not fail to admit the advantage of agreement when the same kind of money, guaranteed by the Government will pass current anywhere in the United States, and, with a small discount for exchange, will pass anywhere in the world.

After some thousands of years of experience and in view of modern conditions of production, it has been found by all the commercial nations that a double standard is impracticable because of the decline in the cost of producing silver, and that gold alone of all the suitable metals has remained reasonably stationary,—that is to say, at a point in production about uniform with demand. There is no probability that deposits will hereafter be found sufficiently prolific to lessen the cost of production and thereby seriously disturb its present value relation as a medium of exchange. There is much wild talk about the volume of money necessary to the world's business. By far the greater part of the world's monetary transactions are now conducted without the presence of money, but upon individual paper representing money which is accepted upon individual credit.

These are all promises to pay money, but the promise is seldom enforced, simply because something else is more convenient. Of course a considerable volume of money is needed, and there has never been a time when the sufficient volume was not in the country. That it may sometimes be put under lock and key by its owners, as happened last summer, has little to do with the subject. The same thing has happened to corn, wheat and pork,—and with the same result, namely, an enhanced price. It is my belief that when the people shall come to understand that all commerce is simply barter, and that gold and all money is simply a material or vehicle to facilitate barter, by being the only commodity in universal demand, the time will have come when theories on finance and political economy will have crystallized, and we shall have no more disasters from cranky tinkering with a subject which only asks to be let alone.

R. D. O. Smith.

Current Topics.

Electric currents of very high tension, ranging up into many thousands of volts, have always been looked upon by a large number of engineers and others interested in electrical matters as belonging to the alternating class. Professor Francis B. Crocker, in his paper on direct-current, high-tension dynamos, which appeared in the February number of this magazine, directed attention to this circumstance by implication, mentioning the existence of the general and deeply rooted idea that continuous current dynamos of very high potential are not at all practical, and that suggestions to use continuous currents for power transmissions are generally confronted with the objection that 1000, or at the most 2000 volts are all that can reasonably be counted upon. The point was made by him that there was no reason why direct current dynamos, of perhaps relatively low potentiality, should not be connected in series, each dynamo generating, say, a current of a few thousand volts, thus raising the total voltage to a figure which would well commend itself in the matter of satisfactory current transmission over long distances. In view of what was there stated, it is interesting to note that exactly this course has been followed in at least one of several recent electric installations in Italy. It appears that at the town of Gênes large quantities of water were stored by damming one of the valleys in the vicinity, and large artificial lakes were thus created. These are at an elevation of about 1800 feet above the town and afford something like 2500 horse-power. The power is used in eleven turbines, driving twenty-two continuous-current generators, and the current is carried over various distances for power purposes, the furthest working point being nearly twenty miles away from the generating stations, and the total length of line operated being about thirty-seven miles. The motors supplied with current range from five to sixty horse-power, and, like the generators at the stations, are all connected in series. The voltage ranges from 450 or 500, to overcome the resistance of the line alone, when none of the motors are in use, to as much as 6000 at the times of greatest power consumption. The current transmission lines are copper wires, about 0.36 inch in diameter, carried on oil insulators on ordinary wooden poles, which, about half-way up, are provided with iron prongs or barbs to prevent unauthorized persons from climbing up. There are also printed notices warning the public against coming in contact with the wires. The whole installation affords an admirable solution of the problem of successfully transmitting high-tension, continuous currents and utilizing them on the series system. The maximum of 6000 volts, now attained, does not, moreover, imply that the full limit of high tension on this system has been reached, and it is intended to soon further increase the voltage to 10,000 by putting in additional generators.

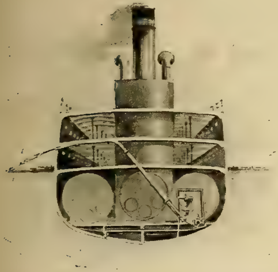
Now that some enterprising genius has proposed to press into service the wave power of the Bosphorus for lighting the Turkish capital, it may not be amiss to call to mind at least one or two of several more modest schemes of wave power utilization that have actually been carried into effect, and that have practically demonstrated wave motors to possess elements of decided value and usefulness. One of these schemes, as materialized at one of the summer resorts along the New Jersey coast, consisted in the use of a thick wooden blade, strongly built, about five feet wide and eight feet long, which was hung from pivots at its upper corners, between two piles of the dock, and was free to be swung to and fro by the waves. Projecting from the upper edge was a rod so connected as to operate a pump which raised water to a tank, from which it was delivered to carts for street sprinkling. The contrivance, it will be understood, depended for its action upon the progressive action of the waves, which swung the pivoted blade. Crude as this apparatus was, it appeared to give quite satisfactory results, and led to the use, a short time later, of a second motor of the same general class, though

A WAVE MOTOR ON THE JERSEY COAST.

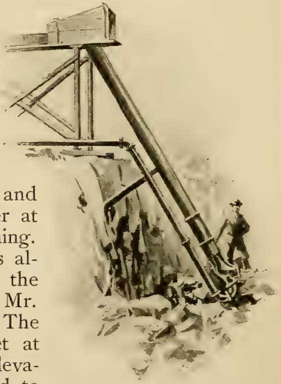
essentially different in manner of operation, depending, as it did, upon the rise and fall of a float acted upon by the waves, and not upon the to and fro motion of a hinged vane. Just what this later motor was like will, perhaps, be best understood from the accompanying illustration, which virtually tells its own story. A timber frame was pivoted at one end between the piles of a dock, and at the other end carried a float, which, of course, was free to rise and fall with the waves. A wire rope extending from the float passed over two sheaves, as shown, and carried a weight at its other end. Attached to this rope was a second one, which passed over still another sheave to the plunger of a pump, the water from which was delivered to an overhead tank. The float weighed about 2500 pounds, and the counterweight 2000 pounds. As the float rose on a wave the counterweight descended and lifted the pump plunger, which performed the return stroke by its own weight, the counterweight being lifted by the falling float. Allowance could be made for the rise and fall of the tide by changing the length of the rope leading from the counterweight to the pump plunger, and provision was also made for lifting the float entirely out of the water when the waves were running unusually high. The pump used had a six-inch bore and a six-foot stroke, and ordinarily filled the 12,000 gallon tank in about seven hours.

It has been estimated that at least one-half of the power expended in the operation of the average manufacturing establishment is wasted in overcoming the friction of lubricated surfaces of shafting and other machinery. This proportion seems excessive, but, after all, is probably not far from representing the actual state of things, and is due, in large part, to the prevailing slipshod manner of valuation of lubricants for different kinds of work. The common system of valuation, in fact, consists simply in a comparison of the market prices of the available kinds of oils with their friction-reducing power and their endurance, when these qualities are known, it being usually assumed that of two oils having prices proportional to their endurance, or to their friction-reducing power, the purchaser might take either with practically equally satisfactory commercial or financial results. The advisability of purchasing is considered to be settled by this comparison, and, as a rule, no comparison is made between the costs of wasted power and the expense of purchase of lubricants even by the most experienced buyers. As a matter of fact, however, the real question is not whether the difference in the price of any two oils is justified by the difference in their intrinsic qualities, but whether the profit to be made in the purchase of the one, rather than the other, is not more than compensated by the cost of the difference in power and in running expenses produced in the mill, or the shop, or wherever the oil is used. In other words, differences in prices of oils are usually of very slight importance as compared with differences in costs of power, and the sooner this is appreciated, the sooner will an approach be made to practically perfect lubrication of rubbing surfaces in machinery. What has been done in the way of investigation into the subject, or rather in the way of reporting the results of such investigation, has generally been of too highly scientific a character to satisfactorily fill every-day requirements. Co-efficients of friction, curves of resistance and ten-inch formulæ may be of great interest to the designing engineer, and of great interest scientifically considered, but their value is extremely low to the practical man who wants to know what kind of oil he should use on his engine and machinery bearings generally. Show him how, with a certain kind of oil for a certain class of work, he can get the greatest amount of good out of his machinery with the least amount of money, and you will appeal directly to his interests in a manner at once intelligible and striking.

MR. HORACE SEE'S hydro-pneumatic ash ejector for steamship use has become a somewhat familiar piece of apparatus to many engineers, and a good measure of how well its advantages are appreciated is furnished by the fact that it is now in service on quite a number of large ocean-going steamers, while on many others its installation is being contemplated. Hoisting the furnace refuse of the coal burned in even a single day under the boilers of a steamship of quite modest pretensions from the fire-room depths to the deck above, and dumping it overboard has always been a task of some magnitude and considerable inconvenience, and it is, perhaps, a matter of small wonder, therefore, that Mr. See's simple method of handling the stuff has so well commended itself. In place of much time-consuming hoisting of ash buckets, a water jet directed into a conveyor tube now does the whole work quickly and effectively, and, moreover, with an entire absence of dust and disorder. Briefly put, the apparatus consists of a hopper, placed in the fire room, and fitted with a substantial cast-iron cover. This hopper opens down into a large pipe inclined upward at an angle of about sixty degrees, and leading out at the ship's side above the water line. Into the bottom of this pipe enters the nozzle of the ejector, from which a jet of water, under a pressure of about 160 pounds per square inch is allowed to issue when wanted. With the water flowing through this pipe or conveyor tube, and discharging overboard, the cover is removed from the hopper and the ashes are simply shoveled in, being caught by the stream of water as they fall, and carried along with it. In order that there may be no clogging, it was found necessary to admit some air with the water, and this is accomplished by placing an air valve in the inclined conveyor pipe. The ashes are removed as fast as they can be shoveled into the hopper, and the whole operation is simple and cleanly. On one of the steamers on which the apparatus is in use and on which about 135 tons of coal are burned daily, the time required for getting rid of the ashes is said to be only about fifteen minutes for each watch.


SEE'S ASH EJECTOR FOR STEAMSHIPS.

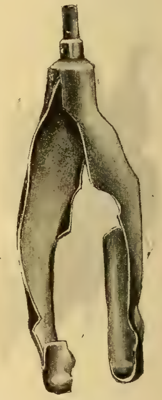
How close a resemblance the contrivance bears to the hydraulic elevator used in the alluvial mining districts of New Zealand is perhaps best seen from a comparison of the two little illustrations on this page. The elevator consists essentially of an inclined pipe, at the bottom of which a jet of water under heavy pressure is allowed to play, and by its action propels through the pipe the gravel and water which enter at its lower opening. The operation is almost precisely the same as that of Mr. See's apparatus. The action of the jet at the foot of the elevator is not limited to the direct force of the water liberated under a heavy pressure, but is also in a large measure aided by the strong suction induced by the vacuum which is created by the upward rush of the water. This suction is also of importance in that it draws the gravel through the opening and thereby does the feeding. At the upper end of the inclined pipe the gravel is deflected by a plate, and proceeds down the usual series of sluice boxes, which are provided along their


AN HYDRAULIC ORE ELEVATOR.

bottoms with riffles and other contrivances to arrest the gold carried in the gravel, from which it separates by the action of gravity. When properly handled, the elevator is a most effective machine, and not only lifts gravel, but also acts as a pump in getting rid of the water used in breaking down the faces of the gravel banks. It is more than a dozen years ago that this machine was first used in some of New Zealand's gold fields and it would thus seem to be entitled to consideration as probably an early prototype of Mr. See's ash ejector.

BOTH of these jet pumps, for such they are, designed for the ready handling of semi-fluid materials, recall a method used several years ago in the Hudson River tunnel at New York for removing the excavated material from the tunnel headings. This material was soft mud or silt. This was thinned to a pretty fluid consistency by adding water to it, and in this state it was forced by the air pressure in the heading, amounting to about fifteen pounds per square inch, through a pipe line leading from a receiving trough to a suitable place for deposit on the surface, some distance away from the mouth of the tunnel. The simplicity and convenience of the arrangement were very striking. No machinery whatever was necessary. The pipes were simply put down and a slight additional tax was put on the air compressors already in use for supplying air to the headings. The whole thing worked to entire satisfaction.

A SOMEWHAT sensational accident, reported and commented on with equal zest by a number of newspapers, recently occurred in England, and has served as a source of alarm to many people who had hitherto considered a lantern lecture to be at least physically innocuous. It appears that a boy, while carrying two cylinders of the conventional pattern used for storing and transporting compressed gases, like carbonic acid and others, stumbled and fell. One of the cylinders, containing oxygen, was thrown violently to the ground and was instantly shattered to fragments, like so much glass. The boy was instantly killed, his head being almost severed from his body. The second cylinder, containing hydrogen, had but a slight fall, and does not seem to have received any injury. Professor Goodman, of the Yorkshire College, at Leeds, England, who was consulted with reference to the accident, prepared a very comprehensive report on the subject, giving a number of interesting figures obtained from tests, both chemical and mechanical, of specimens cut from the exploded cylinder, as well as from another one of regular make, and from tests to destruction of several cylinders selected for the purpose. It would seem, however, that the whole explanation for the accident may be summed up in the simple statement that the exploded cylinder had not been annealed before leaving its makers. Of what slight moment the shock to the exploded cylinder would have been, owing to its fall to the ground, through a distance of only a few feet, providing the material had been properly treated, was very strikingly demonstrated by twice dropping another cylinder, fully charged, from a height of fifty feet on to a block of cast iron, under which conditions the cylinder received small dents, but was not otherwise impaired. The test pieces taken from the exploded cylinder, and from the other one selected for comparison, showed that the steel from the latter was softer, and therefore safer under shock or any sudden stress than that from the former. Still, the material of the exploded cylinder was by no means of objectionable



A RUPTURED GAS CYLINDER.

quality, and could be properly regarded as representing something like one of the limits within which steel to be used in making gas cylinders should fall. The degree of care which is exercised in the construction of such cylinders is perhaps best demonstrated by the circumstance that accidents of the kind here mentioned have been exceedingly rare. The risk of personal harm run by anyone within range of a charged cylinder is, in fact, infinitesimal, and some reassurance may be gathered from this by those who may have been unduly exercised by the deplorable occurrence in question.

THE economy of electric power transmission, as compared with other currently practiced systems of older standing, like those of shafting and belting, has been made the subject of a most interesting booklet, issued a short time ago by the C. & C. Electric Company of New York, and making decidedly instructive reading. So much has been said and written in a general way of the convenience and economy of applying electricity to the driving of shop tools that specific facts and figures, derived from actual experience, are most welcome additions to the literature of the subject, and every engineer must, therefore, needs appreciate the valuable reference data given in the little volume. It is, in the main, devoted to translated extracts from two papers presented within the past year to the Association of Engineers of the College of Liège, Belgium—one by M. Léon Casterman, managing director of the government rifle factory at Herstal, in Belgium, and the other by M. Felix Mélotte, engineer for the International Electric Company at the same place. That portion of M. Casterman's paper which is given in the book, analyzes the electric power installations with which the great rifle factory in question is fitted up, and furnishes, through a collection of interesting figures, a very striking demonstration of the capabilities of this, and by implication, of every other similar electric plant. M. Mélotte, whose company equipped the factory, supplements the information thus given, detailing, among other things, a series of tests made to determine what average power is used in a workshop, and how much power is lost between the prime mover and the several working points. Taken together, the material furnishes an admirable exposé of the important advantages to be gained by electrical transmissions, and should be in every engineer's library. The C. & C. Company, it is understood, supply the little book gratuitously on application as a means of directing attention to what has been made possible in at least one branch of engineering by more recent developments in applied electrity.

As particularly illustrative, however, on the other hand of American, instead of French, conditions and practice it is proper here to call attention also to the paper on "The Economics of Electric Power," by Mr. H. L. Lufkin, of the Crocker-Wheeler Electric Company, presented elsewhere in this issue. Mr. Lufkin shows in a very striking way what has been more recently accomplished in the way of electric motor applications for all kinds of work in different parts of the United States and gives a collection of figures, derived from actual experience, which appeal in a very interesting manner to the owner of every manufacturing establishment using power. The illustrations accompanying the article are correspondingly interesting and suggestive, and, with the exception of a few diagrams, have been reproduced directly from photographs taken at the different works.

THE danger of employing unqualified boiler inspectors was recently well exemplified in a small English town by a boiler explosion which did considerable damage to property in the immediate neighborhood of the scene of action. The boiler in question, it would seem, had gone the way that many boilers unfortunately do go, after having served nearly the full period of their usefulness,—from its last place of fairly safe operation to the paint shop of a second-hand dealer, from which it emerged spick and span, ready to be sold again to someone unacquainted with its history, and eager for a bargain. Paint has a wonderful rejuvenating power over boilers as well as some other things, and with the help of an unprincipled inspector's certificate, soon had this boiler again at work with the result, before long, of a wrecked boiler house, damaged buildings adjoining, though happily, no loss of life, and a bill for the owner for the costs of the usual investigation by the local authorities. The payment of the costs was exacted "as a warning to other steam users who rely upon unqualified, incompetent inspection, because it is cheap, and afterward plead ignorance as an excuse for their conduct."

THE episode pointedly directs attention once more to the subject of cheap boiler inspection and insurance which, off and on, has been condemned for many years, though evidently not with sufficient vigor to have brought about its suppression. Cheap inspection and insurance rates, in fact, seem to possess an allurement to many boiler owners which is quite surprising, when even slight consideration will show that cheap service of any kind in connection with boilers is simply not worth having. It cannot be profitable, but certainly will prove dangerous. England, more than any other country, has suffered from a multiplicity of boiler inspection and insurance companies, and with growing competition among these, and failure on the part of steam users to properly appreciate the value of thorough and conscientious examination of their boilers, decrease in price and corresponding decrease in the reliability of the service rendered, have become natural and unavoidable results. There is a price, as has often been argued, below which a guarantee of faithful inspection cannot possibly be extended without seriously affecting the financial stability of any insurance company. A close approximation to what this price is could probably be made in most cases without much difficulty and any offer of insurance and inspection at a much lower rate should be regarded with suspicion. In the United States, if not elsewhere, the truth of this seems to have been thoroughly realized. Boiler inspection and insurance competition is there at a minimum. The work is practically all in the hands of one company and for a long term of years has been carried on in a painstaking, thorough manner, which has demonstrated its merits beyond all question.

D. Ashworth

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A CALIFORNIA MOUNTAIN RAILROAD.

By Frank Van Vleck.

THE ascent of rugged mountain sides has always exerted a charm to the normally constituted man or to one who can enjoy the deep draughts of mountain air and the views afforded by the large vistas spread before him like a map. Man, as an aspiring animal, is not content until he reaches the topmost notch and, in the same spirit, when a mountain appears before him in his travels, his first exclamation after observing the beauty of outline, is, "I must climb that mountain at the first opportunity." Each summer thousands of vacation seekers rush from their city coops to the cooler mountains, and measure their enjoyment and good fortune by the exact engineering altitude. Recognizing this inherent trait in humanity, why should not enterprising transportation means be provided and maintained on a commercial basis for the satisfaction of mountain climbers? The stage coach supplies this need in a measure, but as the engineer knows, it is the most expensive of all methods of conveyance—"per passenger mile,"—and, as the traveler knows and feels in every bone of his body, it is the most exasperatingly full of fatigue. For the ascent of many mountains of the West it would be impossible to use the stage coach in any form, as only a balloon could lift the coach to the top.

A range of mountains of this class are the Sierra Madres of Southern California. Being precipitous and rugged, it has been impossible to construct a wagon road over or on them. They constitute a great wall, almost dividing the State, and but for two passes would almost form a serious barrier to State unity. At the base of these mountains is located a thickly settled region of fruit farms, with interspersed cities and villages. In the past, hardy climbers had made the ascent to different points, but as their number had been so few and the difficulties which they recounted so great, others were deterred from making the trips. From the plain below, the mountains tower up on the northern horizon to a height of from 4000 to 6000 feet, this altitude being attained in a horizontal distance of from one to three miles, thus, in a measure, indicating roughly the steepness or grade of the mountain slope. Each inhabitant well knew from his geography what a superb outlook could be obtainable from this height. On one side it embraces the major part of Southern California, and to the west, the broad Pacific, dotted here and there with

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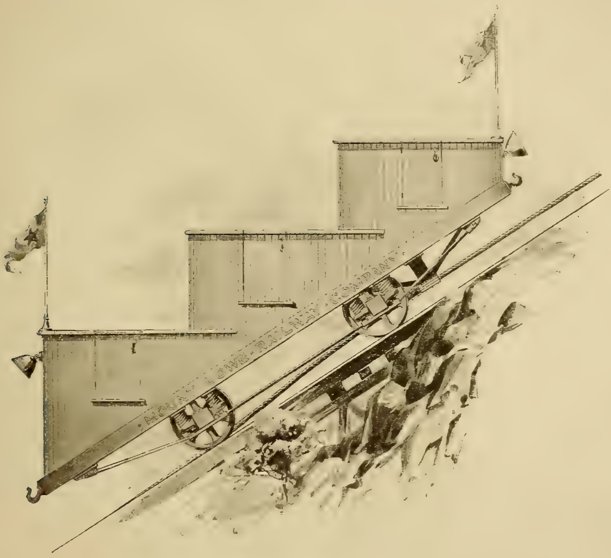
THE ROAD SEEN FROM PASADENA. THE INCLINE IS SHOWN AT THE LEFT.

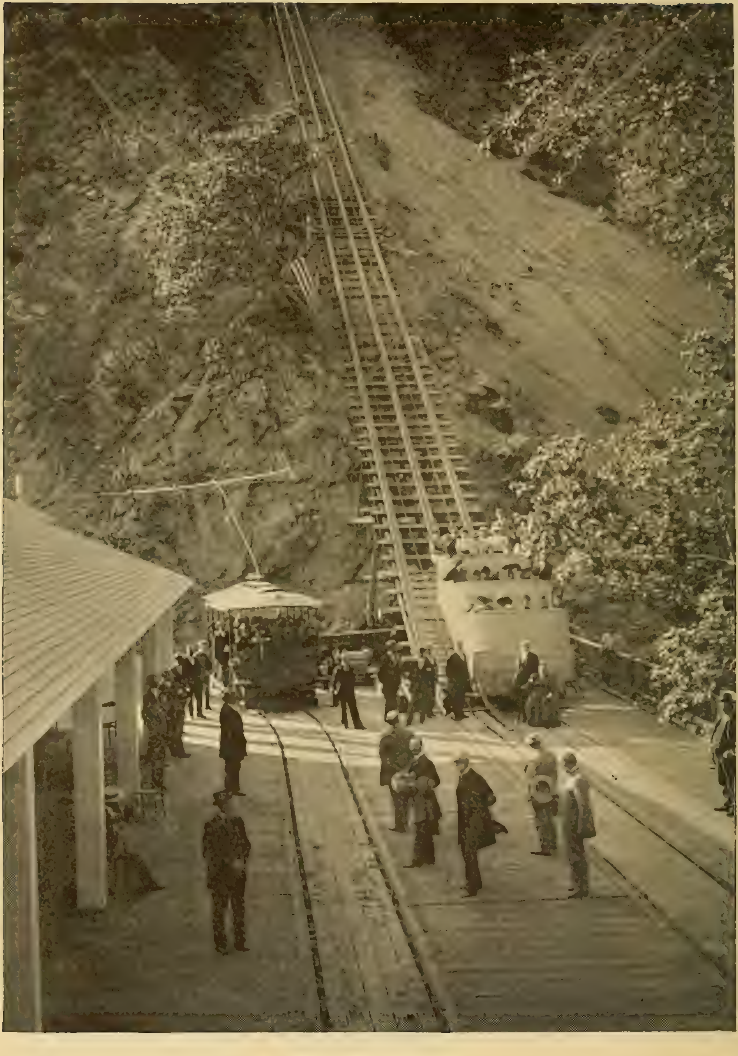
the islands of the channel group.

An enterprising citizen of Pasadena, Cal., Professor T. S. C. Lowe, having had occasion to study the commercial aspects of the inclined mountain railroads of Switzerland, at once saw that equal opportunities and even greater rewards would be obtained by the construction of such a railroad up the sides of this Sierra Madre range, and under his direction a road was soon built and in operation. On the completion of the original surveys for the road, it was found that the grades best adapted for a direct line and for minimum work of cutting and filling, would be the rather unusual ones of between sixty and seventy per cent. The construction and operation of that pioneer in mountain railroads, the Mt. Washington rack road, and also the Pike's Peak & Manitou rack railroad in Colorado, as well as the numerous examples of the Alpine rack roads, afforded no precedent for installing the rack system on such a grade as the one proposed. It was even questioned if the rack system would be safe on such a grade, as it readily can be seen that the safety of the rack diminishes as the grade approaches the vertical. As cable roads can be made safe and practical at any grade, even at the vertical,—for passenger elevators are but vertical railways,—the adoption of the cable system was decided upon. Other incidental advantages obtained by the use of the cable in mountain railroads are that the roadbed construction is somewhat simplified, and the power applied to the car is free from the disagreeable vibrations present with rack roads. Lastly, and most important, comes the fact that the weight of the ascending car is balanced by the weight of the descending car, thus calling for a minimum of propelling effort, since no dead weight has to be lifted at each ascent.

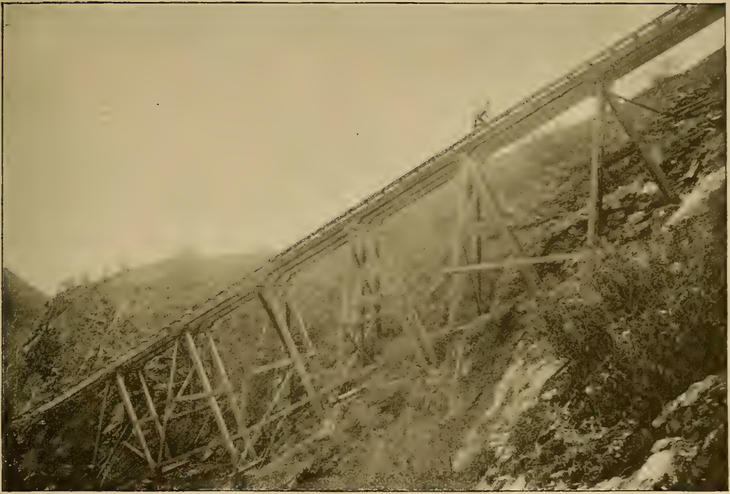


THE "OPERA-BOX" CAR.

In beginning the construction of this California mountain railway, an electric road was first constructed from the

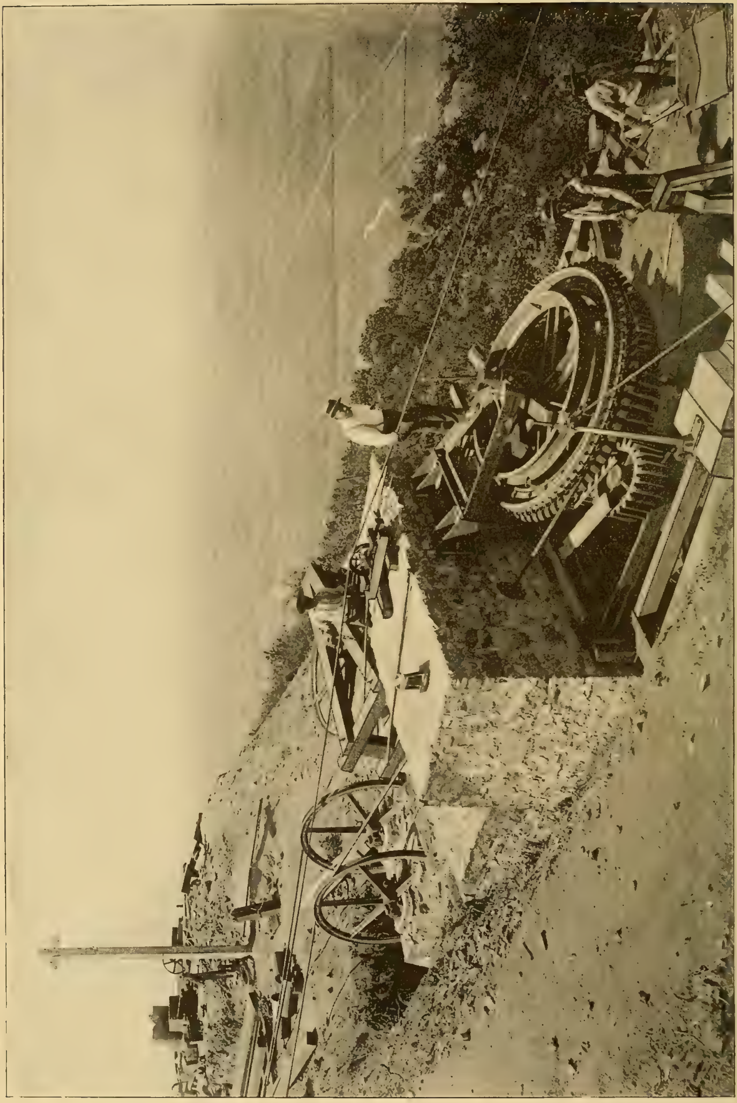


THE LOWER TERMINUS.



A TRESTLE ALONG THE LINE ON A 65 PER CENT. GRADE.

suburban town of Altadena to a mountain cañon three miles distant. This electric road skirts the foot-hills and rises by a small grade, until, passing into the cañon, it reaches the point from which the inclined cable road ascends. On constructing the roadbed for the cable incline it was found necessary to prosecute most of the work from the top of Echo Mountain, the upper terminus, for the reason that, as the grade of the road was so great, the excavated material would roll down the right-of-way with probable fatal results to the laborers on a lower level. This entailed considerable inconvenience, as it necessitated all material to be hauled up tortuous mountain trails on the backs of burros or mules. The form of railroad adopted for the incline consists of the three-rail system, such as has been employed on some other cable roads, among them the inclined road at Chattanooga, Tenn., up Lookout Mountain. This system affords many working advantages, and at the same time does not require as wide a roadbed as would have to be laid down on a double track road, thus realizing a gain in the cost of construction. By the use of the automatic passing place, which can be made the peculiarly advantageous feature of the three-rail form, an absolutely safe passing by of cars can be effected. A further and almost priceless advantage in the eyes of the railroad managers, is the fact that this by-pass is constructed entirely without frogs or switches. It is absolutely automatic, as each car must pass to its own proper side, and in no contingency can it pass to the other side. The road might also have been built on the single-track principle, with a very probable decrease in cost over the system installed. In such a road, the passing place would be the one well known to the operators of single-track street railroads, and would require more or less mechanical appliances to make the frogs and switches automatic. The moral effect on mountain passengers of this one element of insecurity,—possible failure of automatic switches to work,—would react so as to more than counterbalance the

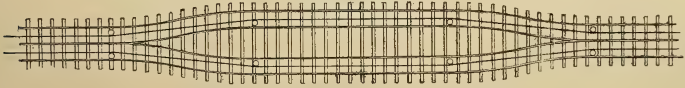


CABLE WINDING MACHINERY AT THE UPPER TERMINUS BEFORE THE MOTOR HOUSE WAS BUILT.

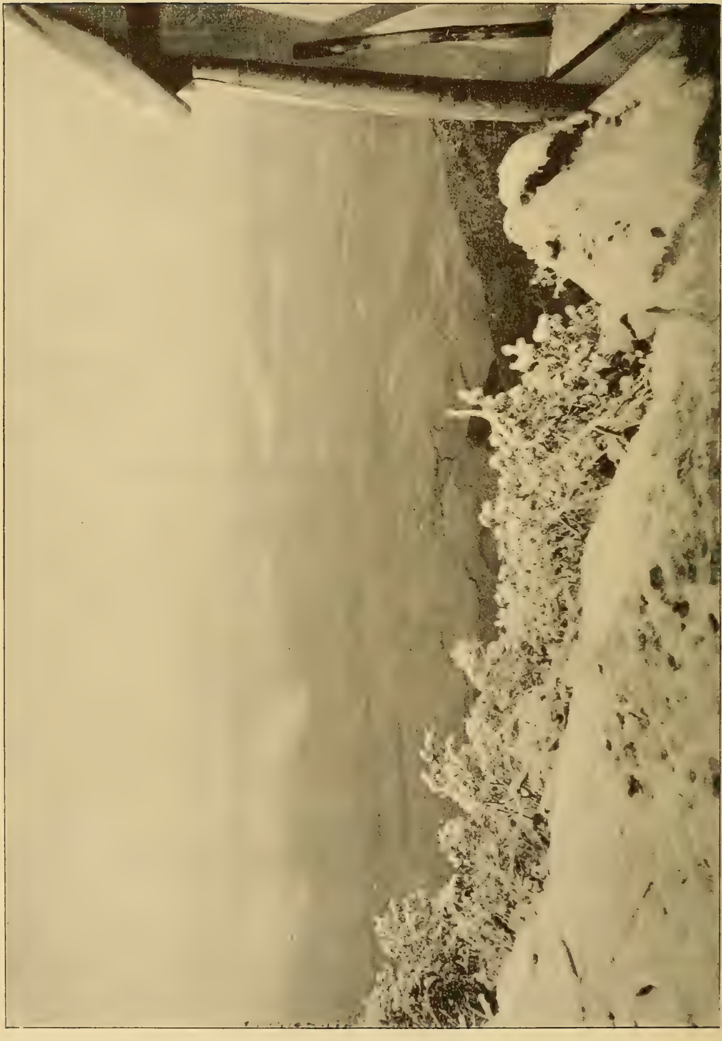
AN IRRIGATING CANAL USING THE WATER DISCHARGED FROM THE TURBINES.

decreased cost of construction. To these passengers there must be no If, for they will not ride if there be the least suspicion that mechanism will give way or fail to act.

The road is 3000 feet long, and makes an upright ascent of about 1400 feet. The steepest grade on Mt. Pilatus in Switzerland is forty-eight per cent. On the road here described there is, on one section, a grade of sixty-five per cent., while other portions have grades as high as fifty-eight. These portions of the Mount Lowe Railway may therefore be properly considered as the steepest railways in the world. The pavilion in Rubio Cañon, at the foot of the incline, is at an elevation of about 2100 feet, or somewhat higher than the hotels in the Catskill Mountains. Echo Mountain, the upper terminus, is 3500 feet above sea level, or as high as Mount Vesuvius. The starting point for the inclined cableway is seen on page 452. The electric cars arrive in front of the Rubio Cañon pavilion, and there transfer their passengers to the cars of the inclined road. Although it is possible to haul ordinary street railway cars on the incline, yet it would be manifestly impracticable on account of the grade. A special car therefore had to be devised. This car, which has been appropriately termed the "opera box" car, consists of three compartments, or boxes, with seats on each side across the width of the car, after the style of seats in foreign compartment cars. As each box is placed above the plane of the one preceding, a level floor is obtained for each compartment. The car has no roof, since

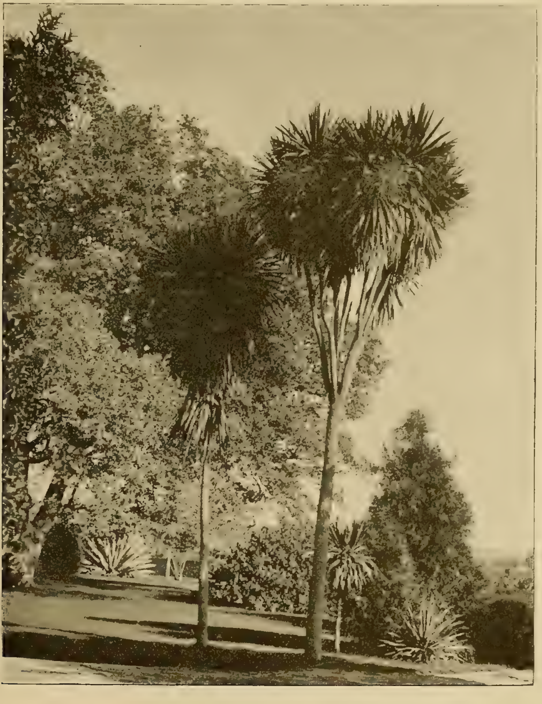


THE PASSING SWITCH.



UPPER TERMINUS OF THE ROAD, WITH A GLIMPSE OF THE VALLEY.

this would entirely shut out the all-around horizontal outlook of passengers in the two upper compartments. Passengers on a mountain railroad seriously resist any infraction of their rights to see all around; and if a roof had with mistaken kindness been provided, masculine passengers would probably have often been found on the roof instead of in their boxes. As the climate of Southern California is even more balmy and cloudless than that of Italy, and as there are rarely more than fifteen or twenty rainy days in the year, the need of car roofs for protection is not urgent. The grip by which the car is attached to the cable is rigidly secured to the under side of the car body near the forward end. It consists of solid clamping jaws, bolted together. A second set of bolted jaws is also provided and kept attached to the cable, to secure the car in case the first set should loosen. This grip can in no way be operated from the car as is the custom with street railroad grips. The car is also kept in communication with the motor house, by the ingenious electrical means of a circuit formed through a trolley line with its return through the traction cable. The relative steepness of the grade which this car is obliged to ascend is shown in the view of the Macpherson trestle shown on page 453.



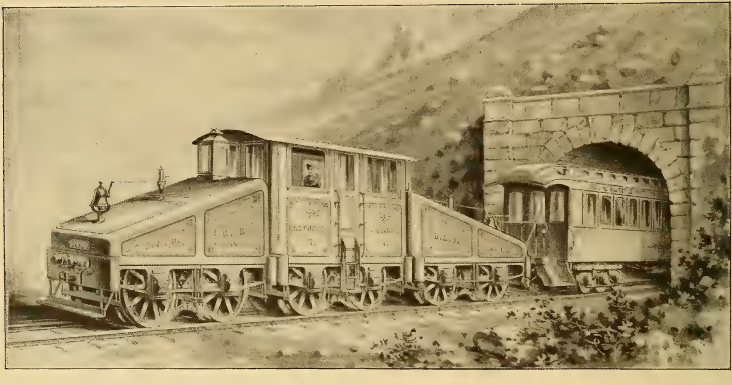
A GARDEN AT PASADENA.

The machinery for operating the cable incline is placed at the upper terminus, and consists of an electrically driven

A MEXICAN COTTAGE AT THE FOOT OF THE SIERRA MADRES.

cable winding system, thus constituting really an electric-cable road. A large drum, ten feet in diameter, furnished with automatic cable clips in its rim circumference, constitutes the pulling drum for moving the cable, and is itself driven by a small spur wheel. The latter, in turn, is connected through bevel gearing with the motor shaft of an Edison electric motor. The current for the motor is transmitted from the electric power house at the foot of the mountains. The whole plant affords an interesting example of the possibility of obtaining power either from water or other means, and then transmitting it electrically to a remote point where the obtaining of either fuel or water is a difficult matter. Temporarily the power house in the valley is being driven by gasoline engines, but eventually all the work will be done by water power, as a fall of over two thousand feet is available. All the movements of the cars on the incline are regulated from the upper motor house, by means of the signals transmitted from the cars. For quickly stopping or for speed regulation, means are not only arranged for the usual control of the electric motors, but, in addition, a band brake is applied to a special brake drum attached to the cable drum. The traction cable employed is one and one-half inches in diameter and of the style usual for heavy cable railway service. It is made endless, and at the bottom of the incline the slack is taken up by an automatic, weighted tension carriage. By the utilization of water for power purposes, many mountain railroads could be operated profitably, while if fuel were required, profit would be out of the question. In this single example it is possible to operate the cable incline entirely by water acting by its weight direct, by supplying each car with a water tank or a separate car carrying a tank. On filling the tank at the upper terminus, the weight of the water can be used to draw up the car at the other end of the incline. Arrived at the bottom, the first tank can be emptied and the process repeated with the other car then at the top. This method may be resorted to as soon as sufficient water can be led to the proper location at the upper terminus. A plant operated with Pelton wheels as in the present case, need not have its entire usefulness end by finally wasting its discharge water, for in the West the value of the water does not cease with the dissipation of its energy. In the present instance it is at once led from the wheels to irrigating canals, and in these goes forth to bless the lands even more than railroads can. One of these small canals leading from the mountain side, is shown on page 455. The results of such irrigation are indicated in the views on opposite page, and on the one preceding, one showing a lawn near the foot of the mountains, giving both the effects of irrigation and the American occupation, while the other, with its wild cactus, shows the more careless existence of the Mexican occupant.

That this mountain cable road has attained such a large measure of success, is due not only to the energy and judgment of its promoter and president, but to the skill as well of its chief engineer, Mr. D. J. Macpherson, who in the work encountered unusual difficulties, and solved them in a manner both simple and ingenious. A general view of the Sierra Madre Mountain range as it appears from the town of Pasadena is given on another page. At the left of the picture will be seen the course of the inclined railway up the mountain side, together with the course of the electric road which forms its approach.



ELECTRIC LOCOMOTIVE FOR TUNNEL SERVICE ON THE BALTIMORE & OHIO RAILROAD.

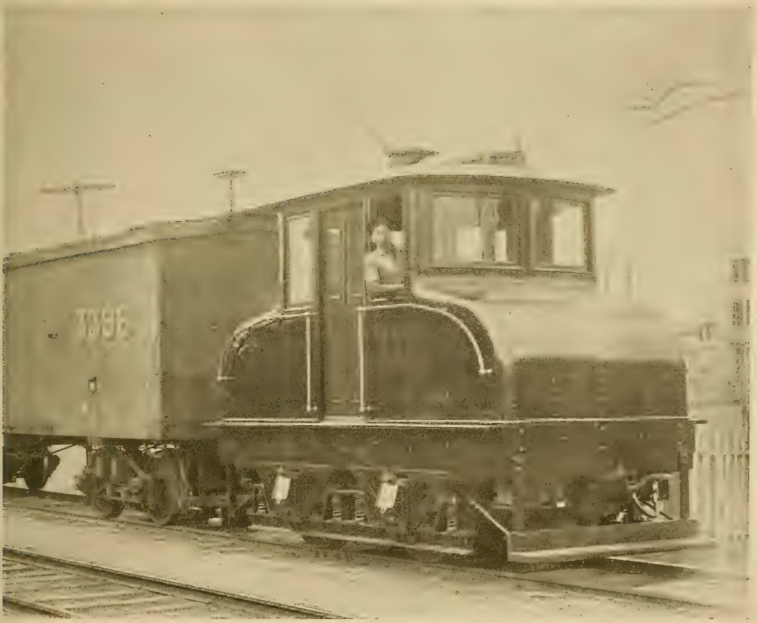
THE ELECTRIC LOCOMOTIVE OF TO-DAY.

By Geo. L. Clark.

WITH all the startling growth in matters electrical, experienced during the past decade, there has, in some few respects, been an apparent species of stagnation, not readily accounted for by the popular mind. The electric locomotive, in its popular conception, among some other things has not entirely materialized in the expected and fondly hoped-for way, and the puffing steam engine that has thus far been so conspicuous in the attempt to annihilate space still reigns unconquered in its special field.

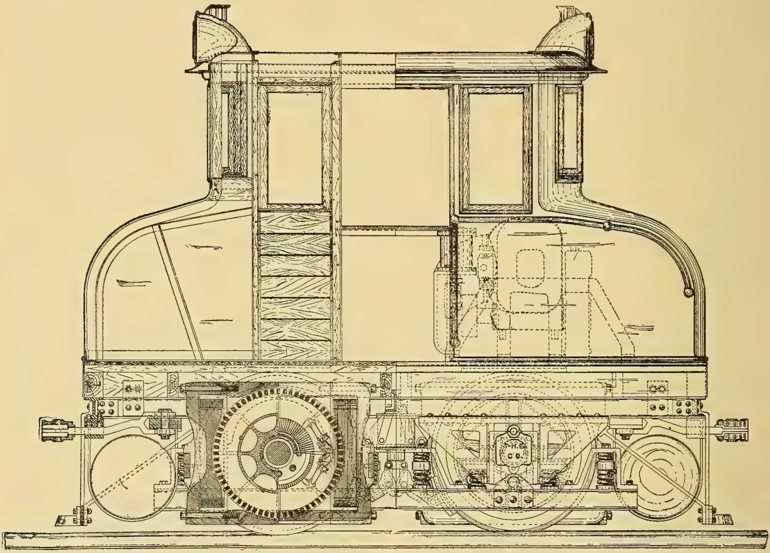
It may seem somewhat strange indeed that what had been thrust into the world with so much flourishing of trumpets and heraldings of early greatness as the electric locomotive, should have stopped almost short in its career, lending to its enthusiastic promoters only the short-lived flush of promise; but, after all, it was not the principle, but simply the form in which it was clothed, that fell short of expectations. Need there be more than brief reference to the marvelous development of electric traction the world over to bear this out? Electric street railroad history is recent and well known and has left no room for doubt that propelling loads over the conventional track system by electric means is far beyond the experimental stage and commercially successful in a high degree. Why the electric locomotive, strictly speaking, considered as a motive power placed at one end of a train of cars in concentrated form, instead of being subdivided over a number of cars as is now usual in electric street car practice, should not be so common a piece of machinery as its steam rival, and why it should not be in direct and lively competition with it at present, is a matter which might well be discussed at length. Space limits forbid going into the matter here. What can be shown, however, in these few pages is that while the electric locomotive has not kept pace in development with other electric machinery, it has by no means dropped altogether out of sight. From the time in fact of what was probably the first electric railroad, devised away back in the thirties by Davenport, until to-day, experiment to turn out a commercially successful locomotive has been unremittingly pursued,—with what result the accompanying illustrations graphically portray.

Edison, Field and Daft have figured prominently in the more recent investigations and the engines of their creation have become quite familiar through text-book and periodical illustration during the past ten or twelve years. The early Field–Edison locomotive, known as "The Judge," and Daft's engine, not inaptly named "Ampère," in fact afforded interesting ocular demonstrations of their capabilities to numbers of people, the one having operated for a short time on an exposition railroad at Chicago in 1883 and the other on the Saratoga, Mt. McGregor & Lake George Railrord at about the same time. It remained for the General Electric Company, however, more recently to make a distinct and decided advance in electric locomotive matters with the 30-ton engine designed and built by them and exhibited last year at the World's Fair. This was the first electric locomotive of any considerable size turned out in the United States and the first practically operative high speed engine of this kind anywhere, adapted to steam railroad service. It was designed for a normal speed of 30 miles an hour and was primarily intended for operation on elevated rail-

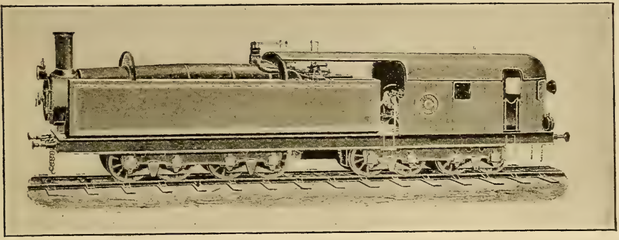


A THIRTY-TON ELECTRIC LOCOMOTIVE, BUILT BY THE GENERAL ELECTRIC COMPANY AND SHOWN AT THE WORLD'S FAIR.

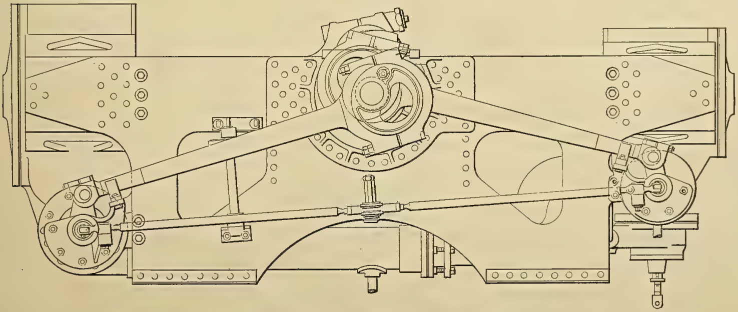
roads and for passenger and light freight traffic on less important steam roads. It runs on four 44-inch wheels, measures 16 feet 6 inches in length, 11 feet 6 inches in height, and 8 feet 4 inches in width, the draw-bar pull being calculated at 12,000 pounds. The propelling power is supplied by two electric motors, one on each axle. The motors are gearless and are supported on spiral springs resting on the side frames of the locomotive truck. This method of suspension leaves the wheels free to adjust themselves to the irregularities of the roadbed, and consequently tends to diminish the wear of both tracks and motors. The motor fields consist of massive iron castings, to which the hollow field spools are bolted. The armatures are of the iron clad type having each separate winding embedded in a mica-lined slot cut into the curved surface of the laminated iron armature body. The axles of the locomotive pass through the hollow shafts on which the armatures are mounted. These shafts rest in bearings of the motor frame, and are connected to the axles by universal couplings, which allow of freedom of motion in all directions. There are four sets of brushes to each commutator. The motors are controlled by means of a series-parallel controller, set up in the interior of the cab.


LONGITUDINAL SECTION OF THE THIRTY-TON LOCOMOTIVE.

The truck, suspended from the journal boxes, is constructed of heavy I beams, and forms the foundation for the locomotive cab, which is of sheet iron, of symmetrical design, and so curved off as to diminish the atmospheric resistance as far as possible. The interior is finished in hard wood. Two sliding doors are placed at each side of the cab, and the windows are so arranged as to permit of an unobstructed view in all directions. There is ample space in the cab for the motorman's movements, and it affords him considerably better protection than that usually vouchsafed the steam locomotive engineer. Air brakes form part of the outfit, the air supply being furnished by an electrical compressor from which the whistle also is operated. To what special service this locomotive will be applied has probably not yet been definitely settled, though its builders argue that the use of engines of this class over very long distances is at present limited only by the cost of long lines of electric feeders. Until the problem offered by this condition is solved, restriction of its employment must necessarily exist. But for places comparatively near each other and where traffic is dense,—the denser the better,—the locomotive is peculiarly adapted, for there all the advantages of electric propulsion are available, unhampered by the extreme expense involved in long feeder lines. At first such engines, it is maintained, will probably be used in elevated railroad service. They will then probably be adopted as feeders to the trunk lines, both for freight and passenger traffic, and to operate short suburban lines, where a rapid, efficient service is requisite. Their peculiar fitness for switching purposes will advance their use another step, and then slowly they will invade the province of the trunk line steam locomotive, and the millennium of railroad travel will be within the realities of life. Unfortunately, however, the promise of attainment of all this is yet too indistinct to admit of much more than idle speculation for the future.

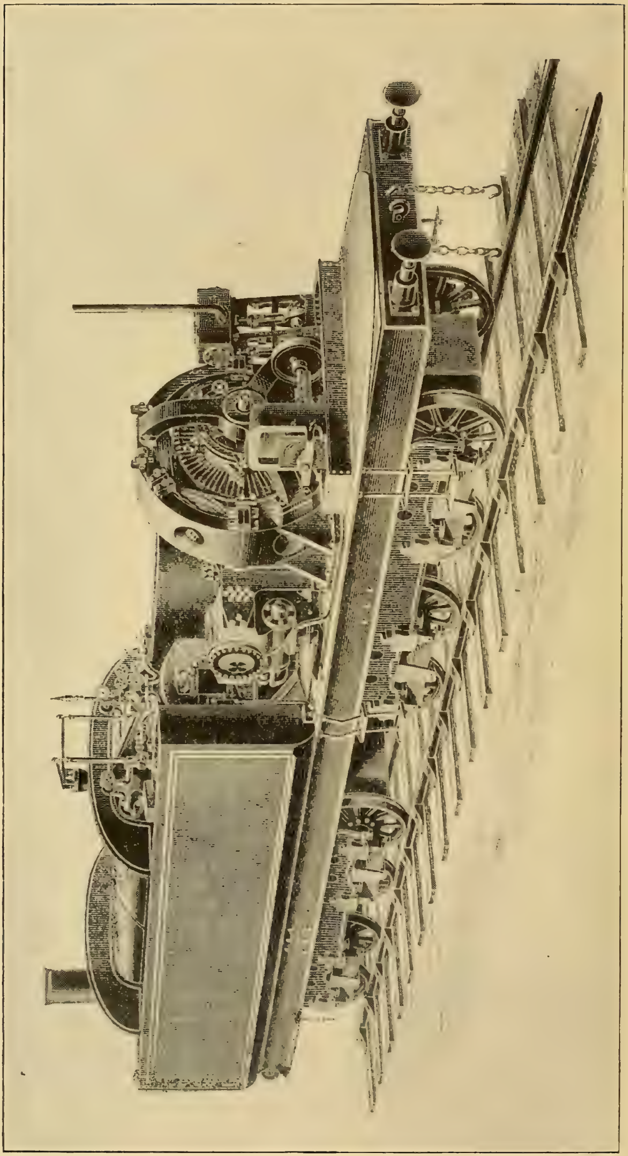


THE HEILMANN ELECTRIC LOCOMOTIVE.



SIDE ELEVATION OF THE MAIN ENGINE OF THE HEILMANN LOCOMOTIVE.

Another outgrowth of the General Electric Company's efforts is a heavy



THE HEILMANN LOCOMOTIVE, WITH WORKING PARTS EXPOSED.

locomotive, intended for service on the line of the Baltimore & Ohio railroad in hauling passenger trains through a tunnel on the outskirts of Baltimore. This engine, while not yet in commission, is quite truthfully depicted on another page. It is designed with three separate trucks, coupled together, and the weight on the twelve driving wheels will amount to 100 tons. The horsepower will figure up something like 1200. The locomotive was designed to haul 500 ton trains at a speed of about 30 miles an hour.

By far the most interesting, however, of the different electric locomotives known up to the present time is that devised by M. Jean Jacques Heilmann, of Paris, of which so much has been said during the past half year, and with which, more recently, interesting tests have been conducted on the Western Railroad of France. These have demonstrated that, if nothing more, the locomotive is quite capable of hauling an ordinary train at high speed. M. Heilmann, it would appear, argued to his own satisfaction that with the currently used railroad track system and the best existing type of steam locomotive, the limit of speed and tractive power had been reached. The disadvantages in the ordinary locomotive of high speed reciprocating parts, of rigid wheel base, and of utilization of only part of the engine weight for adhesion, with the tender always as a dead load to be carried along, prompted him to turn to electrical means of traction. The idea of supplying the electricity from a central station, as in current electric street railroad practice, he abandoned at the outset, considering it impracticable to put down conductors on the ordinary main lines of railroad in their present condition. His original plan, therefore, was to fit up every car in a train with an electric motor, each one to be furnished with current from a generator which was to be placed in the first car of the train, and thus to utilize the weight of the whole train for adhesion. This arrangement, however, precluded the possibility of easily utilizing the ordinary railroad cars. The necessary changes would have been expensive and troublesome. M. Heilmann accordingly came to the plan of using a regular electric locomotive of suitable adhesive weight for the train. The locomotive was to be equipped with a steam engine and a boiler, and with a dynamo to supply current to the electric motors with which the locomotive axles were to be fitted up. The train itself was to be made up in the usual manner of ordinary cars requiring no changes.

A locomotive laid out on these lines was therefore built. Its length over all is a little over fifty-two feet, its height thirteen feet, and its total weight 100 tons. The steam and electrical generating plant is composed of a boiler, a steam engine, a dynamo, and an exciting steam engine and dynamo, all of which are carried on two 4-axle bogie trucks, each of the 8 axles being actuated by a motor, giving, in respect of each axle, nominally about 45 kilowatts each, or a total of 360 kilowatts, equal to 500 electrical horse-power. The load per wheel is 6.7 tons. The boiler is placed on the back bogie, the chimney being therefore at the tail end of the locomotive. It was thought that possibly some slight advantage might be obtained if the stack were at the trailing end, as the gases from the firebox would thus pass toward the chimney in a direction opposite to that in which the engine was moving. This, however, is a minor consideration. The steam engine and the dynamo, together with the exciting plant, are carried on the front bogie, and the centre of gravity is situated near the axis of the trucks, which admits of the longitudinal girders of the frame being comparatively light. In view of the air resistance, it was at first proposed to give to the head or front casing of the locomotive a sharply pointed form ; but experiments having shown that there is no appreciable advantage in this, a convex end was adopted.

The boiler is of the Lentz type, consisting of a shell, in which is fitted a corrugated steel firebox, prolonged by a combustion chamber. The steam engine driving the generator is of the horizontal compound type, designed to develop 600 horse-power. The exciting engine is placed at the front end of the locomotive and is a small, inverted, vertical engine with two cylinders, acting on cranks placed 180 degrees apart.

As illustrative of undoubtedly the most noteworthy departure in electric locomotive design, the Heilmann engine stands out prominently from among others of its class. What part it may take in the supplanting of the more time-honored steam locomotive, however, it is yet too early to attempt to predict.

THE BEST METHOD OF HEATING STREET CARS.

By G. F. Greenwood.

STREET car heating is to-day in an experimental state, and the numerous methods and devices now on the market testify to the endeavor on the part of street railway men and manufacturers to obtain a simple, portable and cheap heater. Treating of this among other subjects in a paper recently presented to the American Street Railway Association, the author divided street car heaters into the following three classes, according to the manner in which they convert the fuel into heat: First, primary heaters, or those in which the heat is obtained from fuel consumed on the car; second, secondary heaters, or those in which the heat is generated beyond the car and transmitted to some storing medium; third, electric heaters, or those of three conversions.

In cable railway practice we are limited to the first two heaters. In electric railway systems we have the choice of one of the three classes; therefore we must consider the means employed to propel the cars, the type of cars, the physical conditions of the railway, and the cost of various kinds of fuel. The elements of climate, distance, and system are considered only secondary in this paper, as these have but little effect in the decision as to which is the best heater. In addition to the foregoing, it will be necessary to consider the mechanical features of heating. The heater should be of minimum weight; occupy as little space as possible; be operated without skilled labor; be constructed of ordinary material; be easily and cheaply removed from the car, and be of such a character that it does not impose additional risks from fire. We will also have to consider the element of pleasing those for whom the cars are heated, and this last will, to a certain degree, govern the adoption of one form or another, providing the difference in operating cost is not too great.

In the first class the author would include all stoves, oil burners, and hot-air heaters. There are many devices on the market for accomplishing a method of heating directly from coal or other fuel burnt on the cars. These can be divided into three classes as follows: Heaters fired from the inside of the car above the floor; heaters fired from the inside of the car under the floor; heaters fired from the outside of the car. If we decide on a heater of any of these classes, the author would suggest using the one that is complete in itself—which occupies as little room as practicable—one that can be fired and operated from the inside of the car, and that uses anthracite coal for fuel.

The plan of operating these heaters on street railways is to have one man to fifty cars, who will clean the stoves, build the fires, and fill the receptacles which carry the supply of coal. The conductor on each car will care for the firing while the car is in transit. Whenever the car equipped with one of these heaters is ready to go into the car station, it is well to have the fire dumped and the hot ashes removed, so that no risk from fire in the station will be incurred. Good heaters of this description can be purchased at from fifteen to twenty-four dollars per car, and can be installed at a cost of about a dollar and a half per day.

The cost of operating heaters of this description per car per day of eighteen hours, may be given as follows : Fuel, anthracite coal, at $4.75 per ton ; labor, at $1.50 per day ; maintenance, 25 per cent. of the cost of stoves ; this makes the cost per car per day, fuel, 8.7 cents ; maintenance, 3.8 cents ; labor, 3 cents, or 15.5 cents per car per day, as an actual cost of operating stoves.

Heaters of the second class are of two types, one using steam and the other water. In the first type steam is used to heat earthenware cylinders or tubes placed in iron pipes, and in the other, heated water is forced into radiating tubes in the cars. These iron tubes or radiators are placed under the seats, with pipes leading through the floors to the outside, where some form of steam or water coupling is provided. At the charging station a rubber hose, connected either with a steam boiler or with hot-water supply, is equipped with some form of valve. When a car reaches this station it is necessary that a man be in attendance to connect the discharge and supply pipes, and to open and close the valves, as the conductor's time will be more or less occupied at the terminus of the trip in accounting for his work. This requires time, and from experience with the first-mentioned type the author would say that it can be accomplished, on the average, in about three minutes. In the water system of storing heat it is well to have the water impregnated with salt, to prevent freezing in winter.

To operate this system of heating it is necessary to have at least two men at the charging station, providing the generating station is located near at hand, so that one man can fire the boiler and charge the cars. This, however, will hardly be possible unless it is on a small road. On a road operating, say, fifty cars, it will require at least four men if all the cars pass through the charging and generating station. This type of heater is at present in an embryo state, and the author cannot give reliable figures as to cost of operating.

Electrical heaters are made of wire or other electrical conductors placed in and around a non-combustible material and heat is generated by raising the temperature of the wire by current taken from the power station of the road. The amount of heat generated in these heaters is proportional to the amount of current used. The heaters, usually four in number, are placed under the seats of the car in such a manner as to have passengers' clothes protected from contact with them. It is necessary to provide them with some form of regulating switch, and the cost per car varies from thirty-five to forty-five dollars, installed. In order to keep the temperature of a car, say, at fifty degrees Fahrenheit in moderately cold weather, an expenditure of from 5.33 to 6.66 horse-power per day of eighteen hours will be required. Estimating the power to cost 0.9 cents per kilowatt-hour, the cost of heating a car per day will be about as follows : In moderately cold weather, using 2.66 horse-power, or 36 kilowatt-hours, 32.4 cents ; using 5.33 horse-power, or 72 kilowatt-hours, 64.8 cents ; using 6.66 horse-power, or 90 kilowatt-hours, 81 cents. To this cost must be added depreciation and repairs, and this can be taken at 20 per cent.

This may appear as an excessive cost for the electric heater, but from the standpoint of expense incurred by heating of cars it must be considered an increment to the expense as a whole of operating the road. This means a certain *pro rata* outlay of money. If the road be at all large, it means the outlay of a considerable amount of money in operating—expense which, simply because it is expended in electric heaters, cannot nevertheless be overlooked, and the heaters therefore should be charged with their *pro rata* cost of the expense of the whole. Some may say that it will cost no more in labor to operate the heater, and the only additional expense incurred would be in the cost of coal ; well and good, but this is viewing the matter rather laxly. If you choose to look at the matter of the expense in this light, you may, but you at the same time admit there and then that the general expense of operating the larger and more important parts of your road is so great that it overshadows the smaller expenses of the road, and they can be lost sight of—in this case that of heating cars. Can you do this? Not if you mean to make every particular portion of the outlay of electrical energy on a road bear its corresponding portion of expense.

Considering all elements that enter into the problem of heating cars, I would say, therefore, that I consider the best method that of using a primary heater—one fired with anthracite coal, and operated from the inside of the car. The reasons which to my thinking substantiate this conclusion are that while a street car is an enclosed space, it cannot be considered as a room, or capable of being heated as easily. It is one open constantly, or at least at very short intervals, to the weather. Therefore a heater which can rapidly counteract any inflow of air is much more appreciated by the passenger than a method of heating which does not, or does not seem to, give out heat so readily. There is a certain attraction in the burning of coal which gives a quiet sense of satisfaction to the passenger. He certainly always feels grateful to enter a street car with a good warm stove in it. This method seems to suit better all temperaments and temperatures. It is a method easily understood by employees, simple in operation and maintenance, economical and efficient.

THE FIRST SYSTEMATIC ATTEMPT AT INTERCHANGEABILITY IN FIREARMS.

By W. F. Durfee, M. Am. Soc. M. E.

THE following papers, although very explicit and comprehensive as regards the facts which they narrate, yet have a close relation to a paper* read by the author at the recent Engineering Congress at Chicago, and therefore seem to require prefatory explanation. When the author undertook to prepare the paper just mentioned, he had reason to believe that there was in the archives of the French Government some very interesting information relative to early attempts in France to manufacture muskets on the interchangeable plan. This it was highly desirable to obtain in order to render the paper historically complete and accurate. He therefore wrote to the Hon. Walter Q. Gresham, Secretary of State, asking him, in the interest of science, to procure, if possible, the information so much needed. He very kindly acceded to this request, and through his kind offices and those of the Hon. J. B. Eustis, Ambassador of the United States at Paris, and the French Minister for Foreign Affairs, the author received the papers, of which a translation is given below. Although this information did not arrive in time for incorporation in the paper, the author takes pleasure in placing it before the mechanicians of the world through these pages.

The information received from Paris furnishes authoritative confirmation of a statement in the author's earlier paper, based upon a certain letter of Thomas Jefferson addressed to John Jay, and dated May 30, 1785, to the effect that the idea of so manufacturing muskets that their parts would interchange with corresponding parts indiscriminately originated in France, and that it is to the highly ingenious mechanicians of that country that the world is indebted for the first suggestion of a method of manufacture which has wrought wonderful changes in mechanical processes, all tending to greater accuracy and economy in their results. M. Blanc, alluded to further on, and his unknown predecessor of 1722 hold a similar relation to the development of the art of interchangeable construction as Watt and Savary do to the employment of the power of steam, and although interchangeability had, in special instances, been achieved before their time, it had not any extended appreciation, and was accomplished by the employment of a degree of skill and an amount of labor from which economy was entirely divorced, and it was not until the project was undertaken in France that any well-defined system was suggested by which excellence and economy in workmanship could be indissolubly united. Just as all improvements in the methods of using steam are but the natural development of the ideas of Watt and Savary, so our improved processes of interchangeable construction are the result of a natural and unavoidable growth and fructification in the human mind of the ideas and methods of the French inventors of the last century.

The appended correspondence and

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* "The History and Modern Development of the Art of Interchangeable Construction in Mechanism."

translated extracts from the documents tell their own story :

(Copy.)
DEPARTMENT OF STATE,
WASHINGTON, December 8, 1893.

W. F. DURFEE, Esq.,
No. 77 Jewett avenue,
West New Brighton,
Staten Island, N. Y.

SIR—Referring to your letters of the 28th of April, 1893, and of the 22d of June last relative to obtaining information from the Government of France concerning the method of interchangeable construction applied to small arms by the French War Office at the end of the last century, I take pleasure in enclosing for your use a copy of a dispatch, No. 81 of the 16th ultimo, from the American Ambassador at Paris transmitting a report on the subject, received by him from the French Minister of Foreign Affairs. I am, sir,

Your obedient servant,
(Signed) EDWIN F. UHL,
Acting Secretary.

No. 81. (Copy.)
EMBASSY OF THE UNITED STATES,
PARIS, November 16, 1893.

SIR—In order to obtain the information desired by Mr. Durfee of Staten Island, I made an official request to the Minister of Foreign Affairs, who has kindly procured the documents herewith :

1. A note, giving historical information on the invention and its application.
2. An extract from an official publication of the time (*Aide Mémoire de 1809*).
3. A report to the Academy of Sciences, dated March 19, 1791.

These documents contain all the information recorded at the French War Office concerning the method of interchangeable construction applied to small arms in France at the end of the last century, in which Mr. Durfee is interested. Being voluminous and not intended for official use, they are transmitted as received for Mr. Durfee.

I have the honor to be,
Very respectfully,
Your obedient servant,
J. B. EUSTIS.

HON. WALTER Q. GRESHAM,
Secretary of State.

(TRANSLATION.)

NOTE.

Relative to an attempt, undertaken in the years 1778 to 1807, for the establishment of the interchangeability of the metallic parts of arms, especially the pieces of their locks. (Archives of the Artillery Committee, 6—c—5 : 6th Division, 1st Chap. File 6202.)

The valuable assistance of the Sieur Blanc, superintendent of the Royal Manufactory of arms at St. Étienne, was appreciatively employed by the many noble officers charged with the design of the models for the infantry musket of 1773, 1774, and especially that of 1777.* These works had acquired a high reputation, and therefore to St. Étienne they committed the application of the ideas they had matured concerning the possibility of making all muskets identical, one with another, and of obtaining them at a lower price. But nothing in the file justifies the inference that the most prominent character connected with interchangeable construction in France borrowed any information from English methods. The advantages claimed by Superintendent Blanc in favor of making each musket exactly like the model were those that all the world is now familiar with, the chief of which consists in the facility of repairs in time of war. M. Blanc expected furthermore by the adoption of his processes to employ simple manœuvres † instead of skilled workmen. He said : "The pieces of which a lock is composed are manufactured separately, and, after the establishment of the system, it will be possible to indiscriminately mix them together and afterward to select at random the pieces for making a lock, and therefore any one can repair a lock with the same ease as he would change the flint." The means by which he proposed to arrive at this result were as follows :

The establishment of standards for the various pieces of the lock, and in order to be able to reconstruct these standards in case of loss or wear, copies of them were to be made for preservation. From the standards were next to be made molds, dies, punches and gauges. It is intended that these tools be given an exceedingly hard temper in order that the workmen may be able to shape any piece of the musket with a file, the edges of the gauges being used as guides, and so that the dies and punches be not distorted by use in giving to the parts, and such holes as are in them, their finished dimensions. In continuation of these operations, slabs, forged at the hammer, are swaged at the drop, and then dressed with cutters on their principal plane faces, after which the holes are pierced. These holes are punched, reamed and drilled by the aid of guides so made as to ensure their being accurately placed, and perpendicular with reference to the plane faces of the work. Afterward these holes are used as governing points for the exterior shapes of the pieces, the file being guided by apparatus of convenient form. The dies and punches also determine with great exactness the position and depth of the "bents" and their relation to the square hole in the hammer. The pieces are finally finished by a special process of tempering by which their shape is not changed. The discovery of this method of tempering obviously constitutes for the system of Superintendent Blanc one of the principal elements of success. According to some scattering indications in the file, M. Blanc intended especially to have recourse to tempering in packets especially designed by him.

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* He had, besides, invented the pistol *M* of 1777, called the coffin, in which all the important parts were carried in a sort of box in its metallic butt.

† Of poor laborers or children, over ten years of age.

Particular importance was attached to the accuracy of the dimensions of the screws and nuts, and Superintendent Blanc often thought of the necessity of employing for all these very uniform taps, and of their change as the result of use. Moreover, the conception of M. Blanc was not limited to the realization of uniformity in the locks, for he was trying hard to apply his process to the furniture of the musket, and above all to the bayonet, of which the interchangeability had augmented interest from the fact that their manufacture had not been attempted by other establishments producing firearms. The first attempts of Superintendent Blanc to obtain uniformity in the parts of muskets by various methods were made previous to 1778, and the results of the manufacture of 200 similar locks for the arms of the regiment of the King appearing sufficiently satisfactory, his processes were generally adopted. By the influence of the Duc du Châtelet and Général de Gribeauval he was appointed on March 18, 1778, as general superintendent of the three manufactories of St. Étienne, Charleville and Mauberge. In fact, after having established uniformity in the materials of the artillery, and invented the spare parts of this material, Général de Gribeauval was willing to extend this improvement to small arms, for which it was at least as desirable.

The opposition encountered by Superintendent Blanc on account of applying to the manufacture processes which were to finally suppress skilled workmen led to the establishment of a special factory for the manufacture of locks. This factory was opened in the Chateau of Vincennes in the month of May, 1786, and M. Blanc commenced to design the tools necessary for the manufacture of the entire lock of the model of 1777; but the revolutionary movements brought about the disorganization of this factory, as well as the suppression of the subsidies. On June 12, 1790, the accounts of the factory at Vincennes were found 72,023 livres ($13,324.25) in arrears, and the closing of the works was decreed in consequence. M. Blanc immediately addressed to the National Assembly a printed memoir (L. M. Cellot, rue des Gr. Augustins, 1790), in which he developed his ideas relative to the manufacture of arms of war, stated the actual condition of that manufacture, eulogized his own inventions, and concluded by advising the establishment of a central manufactory of locks. This memoir was referred for examination to the Academy Royal des Sciences by the Minister of War, La Tour du Pin, and the examining committee consisted of Le Roy, Laplace, Coulomb and Borda, who made a very favorable report on March 17, 1791. The locks manufactured by M. Blanc, to the number of about 1500, were carried to the Hotel des Invalides. The committee, after ascertaining the facts in regard to these locks, concluded that the confirmation of M. Blanc's allegations was perfect, and that the locks had been made like the model, and the dies produced permitted the assurance of the identity of the parts of the locks. After the report of the Academie des Sciences a military commission was appointed by the Minister Du Portail and charged to test the assertions of Superintendent Blanc, who made a certain number of locks under their eyes. The result was a report that the locks made by the methods of the superintendent performed properly, but that they were longer in making, and were therefore more expensive than the locks made by other manufacturers after the old manner. Although approving certain claims of M. Blanc, the commissioners condemned as inexpedient the establishment of a central manufactory of locks.

However, in the year VI. [1797–98] we find M. Blanc established at Roanne as a civil contractor, without, as we may suppose, exactly quitting the service of the State, and on the 13th Vendémiaire in the year VI. [Oct. 5, 1797], he had already delivered 2752 interchangeable locks of the manufacture of St. Étienne. Later, this supplying of locks was extended from the factories of Turin, Liège and Versailles. In the year IX. [1800–1801] M. Blanc claimed to construct the entire musket on the interchangeable system, and that a number should be issued to a body of troops to test the workmanship and put in practice the method of repair of the parts by simple substitution. Notwithstanding that both the products of the factory at Roanne, finished muskets and locks, were turned over to the State at a very high price, M. Blanc was not greatly benefited, and he died in the year X. [1801–1802] leaving 140,000 francs of debts. His nephew Tacony, and afterward a Sieur Cablat, who appears to have been previously one of the lessors of the factory property at Roanne, assumed to continue the affairs of M. Blanc. But the manufacture was started under such poor conditions as burdened it with debt and heavy charges, so that it was impossible to make sufficient money to pay running expenses. A plan of transferring the civil manufacture and workshops to the State, proposed by the First Inspector General of Artillery, did not come to anything, and Cablat, on the invitation of the Chief of Artillery, decided to transport his establishment to Liège, where he hoped to manufacture under circumstances less onerous (Ventose, An. XII. [Feb.-March, 1804].). The factory at Roanne had delivered about 20,000 locks. It was changed into an ordinary factory.

The making of locks at Liège was not more prosperous than at Roanne. The quality of the locks made appeared to be very much like those made elsewhere, and, according to report, they were inferior to the limiting sample. At the end of the year XIII. [Sept., 1804] M. Cablat was declared a bankrupt. He was succeeded by a man named Stiémon, who, it would seem, lent his name to the other contractors. The locks which he made were not satisfactory to the trade, and to improve the manufacture a superintendent was sent from the factory at Versailles (July, 1806). The seizure for the service of the artillery of "the factory for making interchangeable locks," preceded but a short time the closing of this establishment, which was proposed on the 27th of November, 1806, by General Gassendi, Director General of Imperial Manufactures. On June 26, 1807, the suppression of the factory at Roanne was also decided upon. Thus disappeared the last vestige of the courageous attempt of M. Blanc. However, his work was not entirely lost, for the processes which he had advocated penetrated, little by little, those establishments which, of old, were the most hostile to his methods. The parts of locks which were again made in 1810 at St. Étienne and Versailles by the "mechanical process" which they had preserved, satisfied the partisans among the officers of the artillery. The enterprise of M. Blanc appears to have stranded, not so much on account of the very lively opposition which it encountered, as from the warmth of its defenders, and because it was premature.

The means prescribed by M. Blanc for the attainment of similiarity in the parts, were not adapted for a very small product. They must appear to us at the present time so much the more rudimentary, in view of the claim of M. Blanc to have attained absolute accuracy in dimensions. The idea of slight allowances consistent with a good result does not appear to have occurred to him. Moreover, not until the multiplication of machine tools furnished the only means of manufacturing on a grand scale, not with absolute precision, but within the limits of admissible error, did the parts of muskets conform to the modern definition of interchangeability.

(Translation.)
Extract from the Aide-Mémoire de Gassendi.
(Edition of 1809—page 589.)

INTERCHANGEABLE LOCKS.

We will give a description of those locks in which all the parts are perfectly uniform, so that when a number of such locks are taken apart and their pieces mixed and then taken again at random, we are able to reconstruct a perfectly adjusted lock. These pieces are made by heating iron, etc., red hot and putting it into stamps, or dies, and striking it with a "monkey." This mode of making locks by mechanical means was proposed about 1722 and was tried by order of the Government for nearly ten years, and was then abandoned. It was reinvented as new about 1789. M. de Gribeauval ordered a trial, which was long and expensive. The Academy became interested and its committee found the method good. The revolution came; we followed and suspended and took up again this method of manufacture. We made with care some hundreds of these locks, which we submitted to the test of mixing their parts and remounting them, which reproduced the locks with great ease, in the eyes of those without knowledge. In vain we represent to the oily partisans of interchangeable locks (which they have called *simillares*, a name exactly opposite to what the locks were intended to be) that owing to the mode of manufacture, 1st, the iron is made brittle by not being reforged again after having been stamped, which was proved by the larger number of pieces rejected than in the ordinary method, which causes anxiety relative to the pieces actually used; 2d, the dies wear very fast. Owing to this there is necessarily a difference between the first and the hundredth piece, for example. Then, the pieces are no longer exact, the lock cannot have more play, and its uniformity and intent is missed.

The rapid deterioration of these dies is admitted even by their advocates, and it is unfortunately proved by the very high price which they demand for their locks, which, however, they manufacture more rapidly than the ordinary kind, etc., etc. By an official order of the 7th Ventose in the year X. [Feb. 26, 1802], we tested finally, with all the care imaginable, over 492 locks which had wandered for ten years with academies of academies, commissions of commissions, and savants of savants, and which we subjected to the test of dismounting and remounting. One hundred and ninety-two only were in a condition to be used, while the others required very considerable repairs. These repairs were indicative. Moreover, we have the unanswered evidence of the men, given in good faith, without regard to the idleness caused for a year after the manufacture of interchangeable locks was exclusively established, that the idea of these locks ought to be abandoned. We allowed the excitement to cool and then stopped the making of interchangeable locks. We should not say this except for the information of any one interested who thinks he has invented the method and is inclined to take it up. About 1722, it might have been tried to no purpose for 8 or 10 years, and about 1793 we expended 10,000 crowns [about $6,200.00] in pure waste, without counting the subsequent expenses. In the works at St. Étienne, Versailles, we still make many parts of the locks in imitation of those of the interchangeable locks, but do not pretend to exactness, having regard solely to making them very rapidly. We tolerate this method without extending it to other things, in order to avoid all delay in the manufacture, in the belief (with most of the officers of the artillery) that the guns which result are not as good. We think that we shall be able to permit this method for the body of the lock and for one or two other pieces. One of the contractors at the factory offered to make locks for one year 20 sols [about 21 cents] better than the market price, so we permit a method which we call making the locks by mechanical means.

(Translation.)

Report rendered to the Royal Academy of Sciences on Saturday, March 19, 1791, relative to an important memoire of M. Blanc, on the manufacture of arms of war.

Extract from the Journal of the Royal Academy of Sciences of March 19, 1791.

M. Blanc, Superintendent-in-Chief of the three Manufactories of Arms for the use of the artillery, has presented to M. de la Tour du Pin, Minister of War, a

VERY IMPORTANT MEMOIRE ON THE MANUFACTURE OF ARMS OF WAR.

This the minister sends for the examination of the Academy, which charged MM. de Borda, de la Place, Coulomb and myself to render an account of it. In entering into the details necessary to put the society in a position to judge of the plans of the author for the manufacture of arms of war, we intend to examine the means he proposes for putting them in execution and the advantages which they present in their results.

Firearms are subject, as all the world knows, to a great number of accidents, but the most frequent happen to their locks; sometimes one piece, sometimes another becomes old and broken, or in some way fails and renders the arms unserviceable. Sometimes also we are not able to make use of those arms from which some of the pieces are misplaced or lost. It is particularly in the arms in the hands of troops that these accidents occur the most frequently, possibly owing to weakness, which may account for the failure of certain parts of the locks in the frequent drills; possibly by the negligence of the soldiers, little accustomed in general to handle this kind of machine, and it may be possible to employ to advantage a number of the arms which have been rendered unserviceable, in the repair of others, by replacing the piece or pieces that are missing.

This method has a very good reputation in the army in many regiments which, for a certain number of years, have taken care that they were supplied with interchangeable muskets, in order to be able, on occasion, to substitute their locks when one requires to be replaced; but it is easy to see how troublesome it must be, in the case of arms made without precision, to make the parts agree with the lock which we want them to fit, and the pains required to make adjustments which have exactly the same object as that proposed. After these various observations you can easily understand, without our being obliged to add others, of what importance it will be to the army if we are able to manufacture the locks of muskets in a uniform manner, and make the pieces of each kind of which a lock is composed, exactly alike, so that if one of these pieces is broken or lost, we may be able to substitute another so identical that it will fulfill exactly the functions, and that its effects will be precisely the same. We understand that the late M. de Gribeauval introduced all the advantages derived from exact uniformity into all the parts of the artillery of the several departments, but he was obliged to acknowledge that the difficulties which have been encountered in the execution of that project do not pretend to compare with those presented to him in the manufacture of locks in which all the pieces of the same kind are identical, and have the advantages of which we have made mention. Whatever else may be involved, it is these advantages which M. Blanc proposes to realize at the present time, as embraced in the project which he presented to the Minister. But, is this project practicable, and are the character and arrangement of the parts in a lock consistent with its manufacture as suggested? This is what we must examine. It is true that when we consider the principal pieces of a lock, such as the "hammer," the "tumbler" and the "sear," which require special precision in their dimensions, it would seem impossible to practically obtain that which is proposed by M. Blanc. In fact, we have no trouble, even on very slight reflection, in understanding how very difficult it must be, for example, to make a "tumbler" which, when substituted for another in a lock, will agree perfectly with the "sear," in order that the "half-cock" of the "hammer" may be as reliable as before; and that the "trigger" will act as was originally intended, and further, that the "hammer" finds itself situated with respect to the new "tumbler" exactly as it was relative to the old one, so that it will travel over the same space and fall upon the "battery" in the same spot as previous to the change, in order to strike the most fire possible.

However, when we recognize the resources of the arts and the great number of means used in order to attain precision in the execution of the pieces, we cease to regard the project of M. Blanc as impracticable, and are disposed to believe that a skillful man, by employing these means in the proper manner, will be able to attain the result contemplated. The Academy is about to judge from the report that we make to them, of what the author himself does in order to manufacture locks so that all their parts of the same kind may be identical in situation, shape and dimensions. Of this we are about to speak.

In order not to burden this report with superfluous details, we will suppose that the pieces have been prepared at the forge, and stamped by a "monkey" in dies intended for this purpose, in such way that they may be given, by the file, the form which they must have when perfectly finished. However, we will add that, having been witness of the various operations at the forge and "monkey," it appears to us that these were very skillful methods of preparing the pieces without loss of iron or power, and for saving labor in filing. These things being supposed, in order to attain our object, we shall speak first of that oblong plate of wrought-iron which gunsmiths call the "lock-plate," and on which are mounted, by screws, all those pieces which, by their union, really form that which we call a lock. We must regard this plate as a species of plan, on which are marked, by holes, in an invariable manner, all the places that the pieces are intended to occupy. We see, therefore, that this deserves particular attention, and that we should study well the means by which the author accomplishes the drilling of the different holes, for if all the lock-plates are drilled by the same means, the pieces will occupy the same places, and their respective situations will be identical — a condition which, we have already seen, is a point of the greatest importance. The lock-plate having been forged with two trapezoidal projections on the side of the metal, which the workmen very improperly call "pivots," and which were made by the same blow that formed the lock-plate and the "pan" which they call the "nib," they give to the plate the form intended by mounting and fitting it upon another, which has been hardened, and which has precisely the form that the first is to have when finished.

This operation accomplished, we pass to that respecting the holes. They attach the lock-plate solidly to a die of sufficient thickness for directing the drills truly perpendicular. In this die all the holes are drilled exactly in the position and at the respective distances from each other that they are required to be. The workmen commence by marking the new plate with a drill. This done, they finish the holes with another drill, slightly conical. These holes they make cylindrical by means of a tool which they call a "false drill," used with a conductor, in order that the holes shall be exactly perpendicular to both surfaces. Finally, with a finishing bit they give them their finished size, and afterward "tap" such as are to be screw-threaded. By these various operations on the lock-plate, its appearance, as a whole, resembles what was intended, and all the holes are found in precisely the same places as those in the die-plate, and the pieces placed on such a lock-plate will occupy, respectively, the same situations on all other plates made by means of the same die-plate. We will not have any fear of an inclination of these holes (which is prevented by the thickness of the die-plate), causing a change in the position of the pieces, since the holes are all exactly perpendicular to the two surfaces of the lock-plate.

The lock-plate done, it is now necessary for us to see how they give the "tumbler" and the "hammer" their dimensions, shape and the position which they are to have. The tumbler having been prepared, and its large pivot turned, they reduce it to a correct thickness by "milling" its two surfaces, one after the other. They then place it between two jaws, or tempered pieces, of exactly the same form as they desire to give the tumbler, and they file it accordingly; but this does not determine its limiting form. After having been filed, they give it its final shape by passing it through a die made expressly for this use, in order that nothing will be left to desire in the perfection of the "bents" or "notches" of the "tumbler." However, these "notches" must have an exact position with regard to the "hammer," and they make the "square" of the "tumbler" by means of a machine which guides the file of the workman, and which ensures that the sides of the "square" are placed as they should be, in order that the "hammer" shall be perpendicular when at "half-cock," and the "sear" shall find itself engaged with the "bent" or "notch" of the "tumbler" which corresponds to this position. The author employs also several other means, which are well thought out, for giving to the "square" the required form. But all this care would be useless if the "hammer" had not, with respect to the "tumbler," exactly the position which it should have; therefore, the hole in the "hammer" which is to be entered by the "square" is punched in a "die" by a "monkey" in such way that when it is mounted upon the "tumbler" the "hammer" will have precisely its proper position. That part of the "hammer" which turns against the "lock-plate" having been prepared with a "mill," they apply this piece against a very thick "gauge," to which they fasten it, and as this "gauge" has all the form of the "hammer," they file down to it.

They employ similar means for giving the "battery" the form which it must have, as well as the inclination necessary to its face, on which the "hammer" strikes in falling at the place most advantageous for giving fire, and for raising it and uncovering the pan. We have stated the means which M. Blanc employs for giving to the "tumbler" and the "hammer,"—which are the pieces of most importance in the lock—exactness of form and dimensions. We do not undertake to speak of subordinate parts of the lock, such as the "bridle," which sustains the "tumbler," or the "sear," which regulates its movements. We understand without difficulty that, having attained the result of giving precision to the principal pieces, the workman will know how to do the same thing for pieces which are not of the same consequence. We attribute the identity of the parts of M. Blanc's locks entirely to the perfection of the "dies," "molds," "gauges," and "mandrils" which are used in their manufacture. We know now what degree of precision we may attain in other arts in making similar pieces by these means. Finally, it is so far certain that the tempering does not alter the form of the pieces, and that there is no danger that this operation will cause any change which will interfere with their efficiency. However, there is now presented an important question relative to the "molds," "dies," and "machines" which M. Blanc has invented and constructed for making these locks. Is it possible, it is emphatically asked, as these "molds," "dies," etc., wear out, are broken, or lost, to again make others perfectly similar? Will the pieces which may be manufactured with the new "dies" be exactly similar to those which were made before? We believe we can answer affirmatively. In fact, such is the certainty and precision of the means which M. Blanc has employed in the construction of the "types" which are used to form the "molds" and "dies," that we think he is in a position to be able to solve this difficult practical problem.

The result of our investigation is that the project of M. Blanc to make all musket locks in a uniform manner, so that all their pieces of the same kind shall be identical, is very feasible by the means which he has invented. But although we say that it is feasible, it is but an approval of the course which we ourselves have described, and which the author has followed. In fact, having made for some years the muskets for the officers of the old regiment of the King on a special model, he assisted in placing the various spare pieces of the uniform locks of these muskets in separate boxes, so that they would not be lost, and these spare pieces replaced so well those for which they were substituted that the result was the same. But afterward M. Blanc again improved the means of manufacture. We have seen at the "Hotel des Invalides," with many other persons, military and civic, the different pieces of a lock taken successively at random, one piece from each of the boxes containing them; these, when mounted upon a lock-plate, formed a lock for a musket which performed its functions perfectly. This company had under its eyes the proof of what we are about to say. We have actually seen a lock made of parts taken at hazard from the boxes at the Hotel des Invalides, and put together carefully by M. Tillet, and that a "tumbler," made afterward by M. Blanc, and substituted for that which had been used, "assembled" so well with the other parts that the result was precisely the same as before. It is necessary to add that the parts contained in each of the boxes at the "Invalides" were so numerous that they would have sufficed for the "assembling" of a thousand locks.

We see, therefore, that the project of the author is not only feasible, as we have said, but has become a matter of fact, and this with a success which leaves nothing to be desired. We conclude, in consequence, that the means of execution employed by M. Blanc for the manufacture of firearms of the sort that have their locks all formed of parts which are exactly like all others of their kind, and therefore calculated to be substituted one for another, are very well designed and thought out, and their results are confirmed by experience; and that it is very desirable that we make all our arms by these means, which, in short, deserve the praise and approval of the Academy.

Done in the Academy of Sciences, Saturday, March 19, 1791.

(Signed)
LE ROY, LAPLACE, COULOMB,
BORDA.

I certify that this extract agrees with the original, and the judgment of the Academy.

At Paris, the 27th of March, 1791.

(Signed) CONDORCET,
Permanent Secretary.

MANUAL TRAINING SCHOOLS.

By Professor C. M. Woodward.

THE dedication of the Louisville, Ky., School of Manual Training, which occurred a short time ago, was made the occasion by the author of an address on manual training in which the history and character of the subject were detailed at some length. The interest and importance attached to it, however, would seem to make at least brief recurrence to it here desirable.

Manual training, as an educational factor, owed its existence to a widespread conviction that the education of the schools had been dealing too exclusively with the abstract and the remote, and not enough with the concrete and the present. The thought product of the school was too dim and uncertain, and the knowledge gained had no sufficient bearing upon the matters of daily life. Consequently the pupil lacked mental vigor and clearness, and his school experience was deficient in practical elements. Manual training embodies pre-eminently the modern idea of substituting things for words, observation for printed description, and personal experience for the recorded experience of others.

Schools for civil engineering were established some fifty years ago to train men to build the railroads, bridges and canals that increasing traffic demanded. With the steam engine and its application, not only to commerce, but to every field of labor, came the demand for mechanical engineering. Similarly with the development of electricity, electrical engineering has sprung forth in full stature as a new profession.

All these branches of engineering require, as preliminary studies, a knowledge of the theory and use of tools, and the methods of precise and scientific construction. This requirement was met by incorporating shop work into the professional courses, as was first done at the Polytechnic, at Worcester, Mass.; at the Massachusetts Institute of Technology, in Boston; at the State University of Illinois; at Washington University in St. Louis, and at other places in a less marked degree. Then came the thought that tool work and drawing should be classed among the preparatory branches with elementary science and mathematics. With this thought came an effort to reduce the teaching of the theory and use of tools to a science. Let me illustrate the evolution of our methods by analogy. There must have been a time when, with a view to economy and better instruction, some one, reflecting upon the various calculations of the accountant, the builder and the financier, discovered that all numerical operations came under four heads—viz., addition, subtraction, multiplication and division. The suggestion was then made that it would save time to teach those fundamental rules carefully and well before attempting to teach their application. Children could be taught to multiply and divide rapidly while too young to appreciate exchange, taxes and mensuration.

In precisely the same way, after ages of failure to comprehend the problem, the fundamental rules of tool-work have been discovered and arranged in logical order suited to class or individual instruction. It is now seen that old systems of apprenticeship, by which one mastered the use of certain tools and acquired a knowledge of a certain trade, were wasteful and narrow to the last degree. Much time and many opportunities for broad culture were thrown away, and only a narrow and one-sided training was secured. To be sure, tools have improved and multiplied and the stock of materials has increased; nevertheless, the fundamental principles, once recognized, are readily applied.

In manual training, pure and simple, only tools and methods of use are taught. The shop exercises are almost as abstract as in "long division." A mortise and tenon joint typifies nearly everything in joinery—the tenon may be single, double or multiple; it may be plain or dove-tailed, or without a pin or wedge. The joint may be blind or open, rectangular or oblique. In its construction one may use the plane, the try-square, the bevel, the gauge, the saw, the bit, the chisel, the mallet, the knife, the vise, the bench-hook; and it may be put together with paint or glue. However, before an elaborate joint can be properly undertaken, the theory and use of each tool, and how it can be put in order and kept so, should be carefully taught and learned by abundant practice. Beyond a few examples, possibly a single example, of synthetic construction for the sake of illustrating the application of general principles, the manual training school need not go. Similar statements can be made in reference to wood-turning, wood-carving, forging, tempering, molding, pattern-making, metal fitting, etc. Almost the only thing a student should be able to show at the end of his training is the discipline, the knowledge and the clear insight he has gained. If he is able to make a merchantable article of any sort—a bureau, a horseshoe, a chisel, or a dynamo when he is through school—well and good; there can be no objection, but there would be serious objection to his stopping his studies at school for the purpose of making such articles.

It thus appears that the graduate of the manual training school has acquired no trade, though he is familiar with the underlying principles of many trades; he has earned no money, he has learned no business, he has not even an adequate notion of the practical and educational value of his experienced skill. These latter things are not the fruit of schooling; they come from subsequent experience. As the trained gymnast has developed every muscle, co-ordinated physical actions, and learned to use his judgment and maintain his self-control at all times and in all positions, with no definite idea of how such training will serve him in life, so the broadly and rationally trained user of tools does not know in what emergency he will call to his aid the skill and training he has gained here. Both he and the world have yet to rise to a proper appreciation of the trained intelligence which quickly comprehends the thought of a new mechanical appliance and the force of new conditions. It should now be clear that in every craft, whether lower or higher, there are certain foundation principles, mental and physical, which underlie actual practice, and that it is the province of the manual training school to furnish opportunity for the mastery of these foundation principles, and that its claim to be a school for general education permits it to go no further. Finally, in a single phrase, manual education is that department of general training whereby one acquires the mastery of tools and materials.

About the year 1868 Victor Della Voss, Director of the Imperial Technical School of St. Petersburg, published a report giving for the first time the correct method of tool instruction. In his school three years were spent in training and three years in actual technical work. His method, which was that of separating instruction from construction, was not made known in this country until the Philadelphia Exposition of 1876. The credit of calling attention to the Russian educational exhibit is due to President John D. Runkle, of the Massachusetts Institute of Technology, who made a full report of their method of tool instruction to its Board of Trustees that year. In 1877

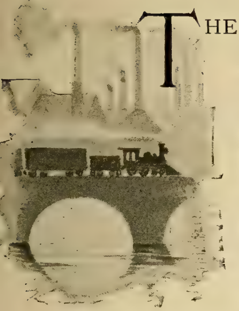
President Runkle opened shops for instruction in tool work, on the Russian plan, in the Institute. Soon after, the School of Mechanic Arts was opened as a sub-department of the Institute for the instruction of mechanics not less than fifteen years old. It had a two-year course of study, including drawing and English studies. The attendance at the school was never large. It was discontinued two or three years ago.

Meanwhile shop work for the sole purpose of instruction had been introduced into the Polytechnic School of Washington University, St. Louis, as early as 1874. In 1877 three shops were fitted for the complete round of tool work, and classes from preparatory schools were admitted. On the strength of that experience a distinct and separate preparatory school known as the St. Louis Manual Training School, was opened September 6, 1880. The course of instruction covered three years, and was very broad and general. This school is now in its thirteenth year, with 300 students, under the charge of a director and fourteen assistants. The immediate and acknowledged success of the St. Louis school led to the establishment of the Chicago Manual Training School by the Commercial Club of that city. The school was opened February 4, 1884. The school has upward of 300 pupils, all seats being occupied. Baltimore opened its Manual Training School on March 5, 1884, as a part of the public school system. Including some classes below ordinary high school grade, its enrollment is upward of 500. Manual training was introduced into the High School of Toledo, Ohio, in December, 1884, and during the following year the Scott Manual Training School was built in connection with the high school building. Under joint management the school is open both to boys and girls as a part of the public school system. Manual training was introduced into the College (high school) of the city of New York in 1884. The Miller "Manual Labor" School, now very nearly a school for manual training, was established at Crozet, Albermarle county, Va., early in the 80's.

Philadelphia opened its Central Manual Training High School in 1885. The school was soon filled to its utmost, and a second one was opened by the School Board. The last report shows that these schools are crowded with a total enrollment of 576 pupils. The Cincinnati Technical School (really a school for manual training) was opened by a corporation in 1886. Following these schools the growth of manual training has been rapid, and the interest is still increasing. It is impossible to give even an approximate list of the schools established either independently or in connection with existing high schools. Nearly every State agricultural and mechanical college has a manual training department of about the high school grade, conspicuously those of Kansas, Indiana, Pennsylvania, Texas, Arkansas, Mississippi, North Carolina and Ohio.

SAMPLING AND TESTING SMALL SIZES OF ANTHRACITE COAL.*

By Eckley B. Coxe, Pres. Am. Soc. M. E.



THE question of how to determine in a rapid, simple and effective manner, the actual commercial value of any shipment of small sizes of anthracite coal, and by methods which do not require scientific work, except for the analysis of the coal, has been carefully studied by me with my assistant, Mr. John R. Wagner. As we are producers to a much larger extent than we are consumers of the small anthracites, although we burn between 100,000 and 150,000 tons per year at our collieries and works for generating steam, we have taken up the subject with the view of controlling our production as well as controlling our consumption, and I shall describe our methods of doing the work, which can easily be adapted by anyone receiving coal in cars or boats to their special case.

The foundation of all such work is the obtaining of fair average samples. This is done as follows: At each of the collieries where the pea, buckwheat, rice and barley are shipped, samples of each size are taken several times a day from the loading lips as the coal is running into the cars. These samples are put into four separate bins, one for each size. At the end of the week the coal in each bin is thoroughly mixed and is then sampled by quartering down until we obtain about thirty pounds, which is sent in a strong canvas bag to the laboratory, thus obtaining from each breaker an average sample of each of the four sizes each week.

The work of taking samples is under the direction of the coal inspector, one being stationed at each colliery, who inspects all the coal shipped. When cars of small capacity are loaded, of which there are not many now, the samples are sometimes taken from the top of the cars instead of taking them from the lips as the coal runs into the cars. With cars of larger capacity the samples are always taken as the coal runs from the lips, getting in each case a very fair average. In taking samples from the top of the smaller cars, eight or ten ordinary buckets of coal are taken from different parts of the car without paying any attention to the character of the coal at the place from which it is taken. The coal from the buckets is placed on a platform and quartered down until about one bucketful is obtained, which is put in the bin. In the other case, where the samples are taken as the coal runs from the lips, they are also put in a bucket and carried to the proper bin. Each of the samples obtained may be used for any of the five following operations: First; determination of size; second, determination of the slate; third, determination of the ash, involving, in some cases, an analysis of the ash; fourth, determination of the water; fifth, rapid commercial determination of the specific gravity of the coal.

Determination of size.—The object of this operation is to determine the exact size of coal which makes up the sample, as distinguished from its nominal size. Fig. 1 is a sketch of the apparatus which we employ. It consists essentially of a cubical box, the top and one side of which are open, and into which slide a series of drawers. We generally use five or six. These drawers are wooden frames $1\frac{1}{4}$ inches deep, about 12 inches wide, and 14 inches long. The bottom is a sheet of perforated metal. The box rests upon a circular base of wood, *C*, which is coned at the bottom and has in its centre a pin, *B*, with a spherical head, which works in a spherical hole in the centre of the wood base, *A*. When the pin is placed in the centre hole the box can be revolved easily, and in such a way that the axis of the box describes a cone. This shakes the coal and causes it to move from one side of the screen to the other, and as it can be moved very rapidly, soon sizes the coal. When the drawers have been placed in the box, a stick of wood, *F*, is inserted as shown in the sketch, thus preventing the drawers from sliding out. The size of the perforations which we usually employ are: For the upper screen, $\frac{7}{8}$ inch round; for the next lower, $\frac{9}{16}$ inch round; for the next lower, $\frac{3}{8}$ inch round; for the next lower, $\frac{3}{6}$ inch round; and for the last one, $\frac{3}{32}$ or $\frac{1}{16}$ inch round.

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*Reprinted from the presidential address on "Small Sizes of Anthracite Coal for Steam Raising," delivered at the last annual meeting of the American Society of Mechanical Engineers. A small part of this address appeared in the January number of this magazine.

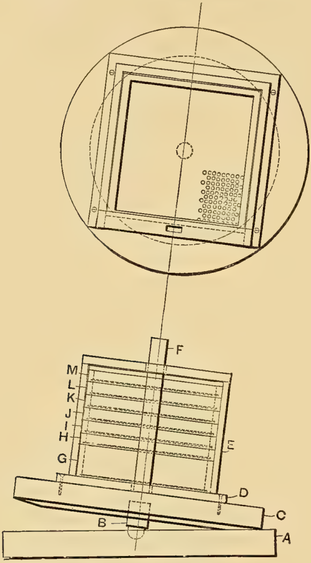


FIG. 1.—SIZING SCREEN.

This makes, with the dust, six sizes. Of course, the number of drawers and the size of the perforations can be varied to suit each special case. If the coal is of the ordinary character, we can screen about fifteen pounds, or about one-half the regular sample brought to laboratory, which is quartered down to obtain the amount necessary to make the determination. It is not necessary to weigh the part to be tested; it is, however, necessary that the entire sample obtained by quartering down should be screened, otherwise you would not have an average sample. The coal is poured upon the screen, which is then gyrated. When the operator is satisfied that the coal is thoroughly screened, each drawer is taken out and the quantity in each drawer is weighed, and by simply adding together these weights, the total weight of the sample is obtained. In this way the average percentage of each size is easily found.

Determination of Slate.—While in large coal the percentage of slate can easily be determined by taking the average sample, weighing out say 100 pounds of it, picking it over by hand and weighing the amount of slate and bone found, it becomes very difficult to do this with the smaller sizes of coal, as a magnifying glass must be used. This is very trying on the eyes and requires a great deal of time. We sometimes resort to it, but only for the purpose of checking our other process. The method adopted depends upon the difference in the specific gravity of the coal and slate. The specific gravity of a piece of coal increases with the amount of ash that the coal proper contains, and also with the amount of bone or slate attached to it. We first determine by analysis the composition of the coal, bone and slate from the mine we wish to study, and also find in the usual way the specific gravity of the specimens analyzed. We thus fix a limiting specific gravity, the particles lighter than which may be considered coal, and those heavier, slate or bone ; and we make a solution of chloride of zinc of the same specific gravity. This limiting specific gravity, of course, varies with the nature of the coal and the nature of the impurities. The coal from the Lehigh region and some parts of the Schuylkill region is much heavier than that of the other parts of the anthracite field, and the specific gravities of the bone and slate also vary with the locality and vein. We use for our mines a solution with a specific gravity varying from 1.70 to 1.72.

The simplest form of the operation would be to take a large beaker glass nearly filled with the solution of chloride of zinc, and pour slowly into it the coal to be examined, stirring it from time to time. The coal floats and the slate goes to the bottom. When the floating coal, which is generally much greater in quantity than the slate, begins to cover the top of the vessel, a portion of it is skimmed off and put in a dish ; and this is continued until all the coal to be tested has been poured into the vessel. The remaining coal which is floating is skimmed off with a great deal of care, the chloride of zinc solution poured off and the slate placed in another vessel. The coal and slate are then washed, dried and weighed, and the percentage of each is calculated. This, of course, does very well if only a few determinations are to be made, but where it is necessary, as with us, to make a large number of tests, an apparatus devised to simplify the work may be used with advantage. Fig. 2 is a sketch of it.

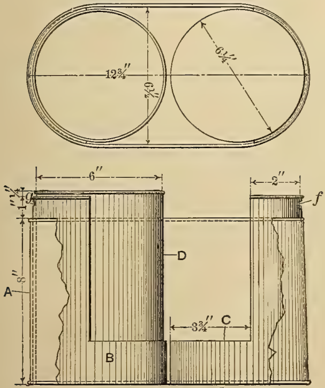
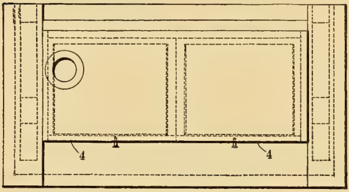


FIG. 2.—APPARATUS FOR SEPARATING COAL FROM SLATE BY CHLORIDE OF ZINC SOLUTION.

It consists of a tin vessel, *A* (which the solution of this density does not attack to any great extent), shaped like an ordinary washboiler, or, more properly, two half cylinders joined by a rectangular parallelopipedon. The depth of the vessel is eight inches, the extreme length is 12¾ inches inside, and the width 6½ inches where the sides are parallel. The two cylinders, *B* and *C*, the bottoms of which are closed by a wire gauze of No. 24 wire mesh, for two inches above the wire gauze are complete, but, higher up, a little more than one-half of the circumference is cut away. These are placed in the outside case, *A*, with the open sides facing each other. Inside of the left hand one, *B*, is placed another tin cylinder, *D*, of slightly less diameter and without any bottom, which when in position extends from the wire gauze up to the top of the main case.

When the parts are in these positions, the vessel *A* is filled with the chloride of zinc solution to within about one inch from the top. The coal is then poured gradually into cylinder *D*, and is stirred continuously until all the coal has been poured in, and the pure coal has risen to the top. By raising cylinder *D* about 2½ inches the pure coal can be transferred in it as it is floating to cylinder *C*, when the cylinder *D* is lowered into *C*, while the slate remains upon the gauze of cylinder *B*. Cylinder *B* is then raised above the liquid and hung on a nail by the hole *g*, which allows the liquid to drain back into vessel *A*. Cylinder *C* is then raised, with cylinder *D* inside of it, out of the liquid and allowed to drain, the coal resting then upon the gauze bottom ; the two are hung together on a nail immediately over vessel *A*. After two or three minutes' draining, the coal and slate are washed in the cylinders in which they are; that is, the slate in cylinder *B*, and the coal in cylinder *C*, cylinder *D* having been removed, unless there is a large amount of coal, in which case they remain together. They are then removed to the drying apparatus, to be described further on, and after drying the coal and slate are weighed, and the percentage of slate calculated. A number of experiments have shown us that this method of determining the percentage of slate gives results practically as accurate as those obtained by the most careful selection by eye; although it is possible that in the selection by eye some few pieces might change places. It takes but two or three minutes to make a determination, outside of the time necessary to dry the coal, which is from five to six minutes. So that with the single apparatus five or six determinations can easily be made in an hour by anyone of ordinary ability and carefulness.



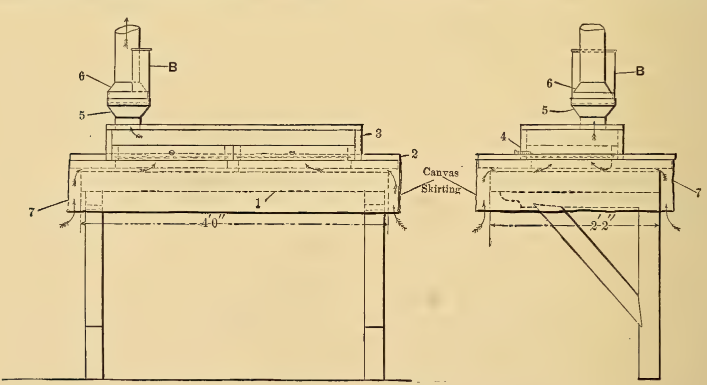


FIG. 3.—APPARATUS FOR DRYING WASHED SAMPLES OF COAL.

As we have constantly occasion to dry coal, which in the ordinary way takes considerable time, a simple apparatus was erected to do the work. It consists essentially of a rectangular iron case (see Fig. 3), about 4 feet long, 26 inches wide, and 4 inches high, cast hollow and as thin as possible. This is kept filled with steam; on top of this is placed a box made of wood, with side openings, on the projecting bottom of which there are two drawers, 18 inches long and 16 inches wide. The sides of these drawers are of wood and the bottom of 24-mesh wire gauze. The bottom of the box, which is about one inch thick, covers the whole iron plate, and extends about one and a half inches beyond the edge all around. From the outer edge of the cover a canvas curtain about six inches long is hung. The projecting bottom board is about one inch above the iron plate, leaving space for the hot air to pass through. The bottom of the case is cut out where the bottom of the drawer is covered with the gauze, and the whole box rests upon the plate, so that air passes around and over the plate, and up through the gauze. The top of the box is closed, with the exception of one hole, in which is inserted a sheet-iron pipe, which connects with a suction fan. The result is that a constant supply of air passes around the iron plate, through the holes in the wood cover, and then through the gauze to the suction fan, by means of which a very rapid drying at a comparatively low temperature is brought about. In order to dry the coal and slate from the chloride of zinc apparatus, the pipe between the drying apparatus and the fan is enlarged, as shown in the sketch, so that by removing the cap on the upper part of the enlarged portion of the pipe, the cylinders *B* and *C*, or *C* with *D* in it, can be inserted in the enlarged portion, the cover put on and the drying of this coal and slate carried on without interfering with the drying in the other parts of the apparatus. This apparatus is very simple and inexpensive, and is very satisfactory and thorough in its work.

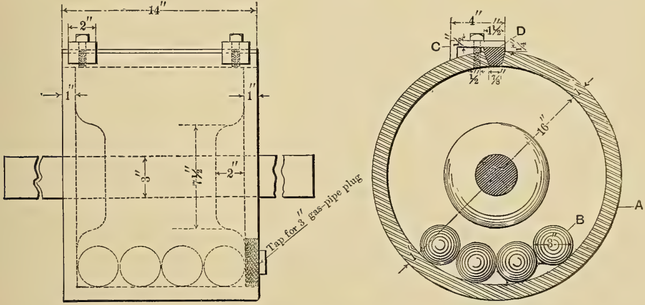


FIG. 4.—PULVERIZER.

While not of very great importance, yet it may perhaps be well to give our method of preparing the solution of chloride of zinc, with some details as to its cost. We use a three-gallon crock, such as is sold in the ordinary china stores, in which we place about five or ten pounds of scrap zinc, which is generally the old zincs taken from our telegraph batteries; but, where this is not on hand, any scrap, which can be purchased for about three and a half cents per pound, will do. We fill the crock with common hydrochloric acid, 1.20 specific gravity, and cover it with any kind of lid of crockery. The important point, of course, is to have an excess of zinc, which is not wasted, but which is used in the next operation. When all action ceases, the solution is decanted, and is of a specific gravity of from 1.5 to 1.62, which we increase by evaporation in a common shallow tin dish over a low heat burner or any other source of heat to a specific gravity of 1.75. The solution costs, when thus made, about seven cents a pound. The zinc solution at the end of the week (when we have made about 40 tests) becomes dark from the coal dust, and we filter it by filling a quart funnel a quarter full of ordinary mineral wool and allowing the solution to drip through. This is always done on Saturday afternoon, so as to begin the week with a clear solution. To keep up the specific gravity, a small quantity of the heavier solution is occasionally added.

Preparation of Sample.—The sample which comes from the colliery in the canvas bag, on reaching the sample room of the laboratory, is divided into two parts, one of which is dried (should it be wet) in the apparatus already described, and then goes to the pulverizer. The latter consists of a cast-iron cylindrical shell (Fig. 4), 12 inches long and 16 inches in diameter (both inside), through the centre of which passes an iron shaft, and inside of it are 16 chilled cast-iron balls, *B*, 3 inches in diameter. The cylinder makes from 70 to 150 revolutions per minute, according to the number of samples to be prepared. Along the surface of the cylinder, and parallel to the axis, runs a slot which is $\frac{7}{8}$ inch wide on the inside, and 1$\frac{1}{2}$ inches wide on the outside. This is closed by a wrought-iron wedge, *D*, which is held by two clamps, *C*, placed near each end. By bringing the slot to the top, the coal may be poured in, and by bringing the slot to the bottom, the coal can run out, the cylinder being oscillated backward and forward in order to remove all the stuff, which is received in a Russia-iron pan 24 inches long and 18 inches wide. In this way the whole of the pulverized product can be rapidly removed. We generally put about 15 pounds into the pulverizer at once. Running at a moderate speed it takes about 1$\frac{1}{4}$ hours to pulverize 15 pounds of pea coal thoroughly; but by crushing it in a mortar so that the coal will pass through a 9-16 round mesh, this time can be very materially reduced. Buckwheat, rice and barley are pulverized without any previous hand crushing. Rice and barley require only about three-quarters of an hour. The pulverizer is a very simple, cheap and effective machine. The surfaces of the slot are planed, as is also the wedge, making a perfectly tight joint, and not allowing any dust to escape.

The pulverized coal received in the pan is quartered down to about one pint, which is screened on a No. 60 mesh sieve, 90 per cent. generally passing through, and that which does not pass through is crushed finer by hand on a rubbing plate, requiring but a few minutes. The anthracite coal of the Lehigh region, containing on an average not more than 5 per cent. of volatile combustible matter, might be pulverized so as to pass through a No. 80 mesh sieve, which would shorten the time of ash and sulphur determinations, especially if, for the incineration in the former case, oxygen be not used; but as we use oxygen, and only occasionally make sulphur determinations, we make the sample only fine enough to pass through a No. 60 mesh sieve. Where no machine is available for pulverizing, and the work must be done by hand, it is important to crush the whole sample until it will pass through a sieve of No. 4 mesh, quarter down, then crush the retained portion until it will pass through a No. 10 mesh, then quarter and crush the retained portion until it will pass through No. 24 mesh, and so on until the last sample will all pass through a No. 60 mesh. But no effort should be made to shorten the work by crushing the sample roughly, and screening it over a 60 mesh and using what passes through for analysis. Our attention having been called to the discrepancies in analysis where we attempted rapid crushing in this way, we made a series of careful experiments, the results of which are given in the following table, to satisfy ourselves as to the facts. The first column gives the sizes of coal, the second column gives the percentage of ash when the proper method of sampling is adopted, the third column gives the results when the rapid method of sampling was adopted, and the fourth column gives the difference in each case.

Results of Comparison of Two Methods of Obtaining the Powdered Samples for Analysis.

Size.	Method "A." Per cent. of ash.	Method "B." Per cent. of ash.	Difference per cent.
Lump coal........	5.00	6.65	1.65
Broken coal......	7.52	9.97	2.47
Egg coal..........	8.50	11.12	2.62
Stove coal........	8.39	10.15	1.76
Chestnut coal.....	9.50	12.87	3.37
Pea	11.45	14.95	3.50
Buckwheat	9.87	11.27	1.40
Rice..............	13.85	17.95	4.10
Barley............	13.05	23.95	10 90

It will be observed that the difference was as much as 84 per cent. in the last case. The reason of this is probably that a large portion of the impurities in coal, such as iron pyrites, silica and substances of a clayey nature, occur in very light incrustations upon the surfaces of fracture of the coal. During the crushing a great deal of these very thin films is rubbed off in powder, so that the fine dust which passes through the 60 mesh sieve contains a very much larger portion of these impurities than the average coal. This is especially the case with the iron pyrites, which is often found in films scarcely thicker than tissue paper, which, during the crushing of the coal, is reduced to a very fine powder. Although we have not yet made a determination of the sulphur in the case where the 84 per cent. difference occurs, I should expect to find a much higher percentage of it in the sample prepared in the wrong way than in the sample prepared in the right way.

Proximate Analysis of the Coal.—For commercial purposes, which is the point of view from which I am treating this subject, only a proximate analysis of the coal is generally necessary; that is, an analysis by which the moisture, volatile combustible matter, and ash are determined, the carbon being determined by difference. It is necessary only occasionally to determine the sulphur, and more rarely the composition of the ash, as the sulphur and the composition of the ash do not vary in the coal from one colliery as much as the percentage of ash. It would not be necessary to determine very often the moisture and volatile combustible matter were it not that, without them, the amount of fixed carbon cannot be arrived at. The sample, which has been pulverized and quartered down until it will about fill a pint measure, is sent to the analytical room, where it is subjected to the following operations, if all be necessary: Determination of ash; determination of moisture; determination of volatile combustible matter; determination of sulphur and analysis of ash.

Ash Determination—The sample to be subjected to analysis is obtained by spreading the pint of coal upon a sheet of glazed paper, thinning it out, and then dividing it by cross lines into a number of divisions. From each of these a small quantity is taken, making up the two grams generally used. The incineration is done in a light platinum dish of special shape. (*A*, Fig. 5.) It is practically a thin sheet of platinum 3$\frac{7}{16}$ inches long by 2$\frac{3}{4}$ inches wide, with a central depression 2 inches square, and 1-32 inch deep at one end, and $\frac{1}{4}$ inch at the other. This is covered with a lid made of thin sheet platinum, 4$\frac{1}{2}$ inches long and bent as shown at *B*. The dish is supported on two platinum wires laid across between two ordinary firebricks, between which Bunsen burner is placed (*C* and *D*, Fig. 5). The dish can be slightly inclined by allowing the right hand wire to drop into a crevice about $\frac{1}{4}$ inch deep in the firebrick. The lid and end surfaces of the dish form inclined surfaces which deflect the flame of the burner, and cause it to travel to the left hand corner, thus creating a slight suction at the end of the lid, and increasing the amount of air passing over the incandescent coal. The under side of the lid, being polished platinum, reflects the heat down upon the coal, and increases its incandescence, thereby hastening the burning out of the carbon. We tried a lid of Russia iron, but instead of increasing the incandescence, it absorbed the heat and retarded the operation. One of the great advantages of the shape of the dish is that the sample can be spread in a thin layer, and the current of air or oxygen directed over it, and also that the incandescent mass can be easily stirred, the lid being conveniently lifted with a pair of forceps.

With these dishes, when incinerating two grams and using natural draft, the operation is completed in about one hour, and the coal need be stirred only two or three times. For making ash analysis, we can incinerate five or six grams in the same way in very little more time, as the surface exposed to the action of the air is so great. In an ordinary platinum crucible, with air, it would require from three to four hours for one gram. Of course, I am talking only of anthracite; bituminous coal burns very much more rapidly when treated by the ordinary method. In order to hasten the process, which is a very important point where so many analyses have to be made, we use oxygen, which we obtain in tanks, at a very high pressure, from the New York Oxygen Company. A tank containing 20 cubic feet of gas, at atmospheric pressure, is sufficient for from 75 to 100 analyses. With oxygen the operation is performed as follows :

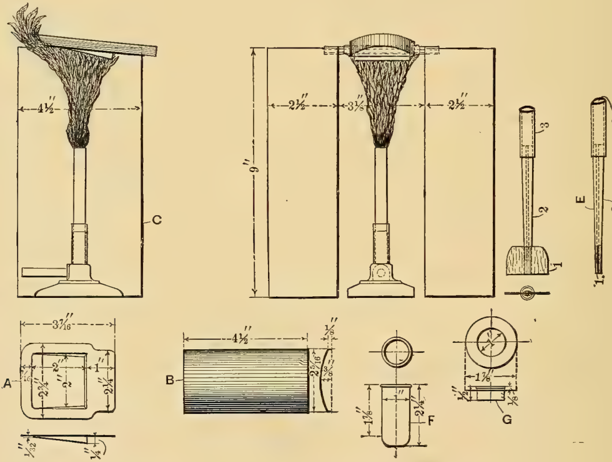


FIG. 5.—INCINERATING DISH AND SPECIAL CRUCIBLE.

After the coal and dish have been heated to redness, a gentle stream of oxygen is allowed to pass over the coal for twenty minutes, after which it is transferred to the other apparatus, immediately alongside, where the same operation is allowed to continue for twenty minutes more, with a current of air passing under the lid. By having these two apparatuses, one man is able to make about twenty ash determinations of two grams each in ten hours. The flame, as shown in *C*, Fig. 5, is deflected to the left, and on the right hand side comes to about the lower corner of the dish. The dishes were made to order by John C. Entriken, Malvern, Pa., and weigh from 21 to 22 grams each. The dimensions are all given in Fig. 5. The lids, *B*, are 2⅝ inches by 4½ inches, No 40 *B. & S.* gauge, and weigh from 13 to 15 grams each. The wires which support them are also of platinum, 4 inches long and 1/16 inch in diameter, weighing about 4 grams each. The two dishes with which we have already made over 800 determinations are still in fair condition. The right hand end of the dish is made deeper, first, to avoid loss in consequence of the material sliding down when it first becomes heated ; and second, to give more inclination to the under side of the dish, and thus deflect the flame of the burner to the left. The oxygen is brought from a tank by an ordinary india-rubber tube (Fig. 5, *E* 3), which is terminated by a clay pipe (a piece of tobacco pipe), at the end of which is placed a piece of platinum foil, flattened out as shown in *E*, Fig. 5. This is merely wrapped round and flattened with the fingers, its object being to distribute the oxygen uniformly over the whole width of the dish. We find in our laboratory, where the pressure of gas is low, that it is much easier to incinerate the coal in the flat dish than in a crucible, for the temperature produced by the burner, when the supply of air is restricted, as it must be with low pressure gas, is hardly great enough to incinerate in a crucible, while there is no difficulty with the dish, and hence results in economy of gas consumption.

Moisture Determination.—This is done in a very simple apparatus, constructed as follows: Two 1-inch boards, 12 inches wide and about 8 inches high, with the upper corners rounded off, form the back and front. In each of these boards there is cut an opening, 10 inches wide and 4½ inches high, also rounded, in which there is placed a copper muffle made of sheet copper, 1-16 inch thick, simply bent in the form desired, riveted at the joint and open at both ends. This is tacked to the two boards. Both the front and back of this muffle are closed by a piece of asbestos board supported on two tacks. Another piece of asbestos board is bent around so as to form the sides and top, leaving a space between it and the muffle, about an inch wide. Underneath the muffle are four very small gas jets, formed by making four small perforations in ⅛ inch gas pipe. These give the heat which keeps the muffle hot. To remove the products of combustion resulting from these jets, four holes, ⅜ inch diameter, are cut in the top of the asbestos casing. A thermometer passes through the top of the muffle and the asbestos board top, and shows the heat in the muffle. The piece of asbestos board at the back is not taken off; that in front is removable, in order to allow the sample to be put in. By means of these gas jets the temperature is kept at about 225 degrees Fahrenheit, and remains remarkably constant with but very little attention. Any ordinary mechanic can construct this apparatus in a few hours. The sample, when weighed out, is placed in the muffle, and remains at a temperature of 225 degrees Fahrenheit for about one hour, experience having shown us that this time and this temperature are best suited for determining the moisture in our anthracites. Notwithstanding the extreme simplicity and low cost of the apparatus, it gives results which are very satisfactory.

Determination of Volatile Combustible Matter.—For this determination, the method usually adopted is to heat the sample in a covered platinum crucible for 3½ minutes, by an ordinary Bunsen burner, and then, without cooling, for 3½ minutes more with a blast burner. We find it very convenient to adopt a crucible of special shape, provided with a flanged sleeve (*F* and *G*, Fig. 5). The crucible is 1 inch in diameter, 2¼ inches deep, and cylindrical for a length of 1⅞ inches. It is wire rimmed at the top, and fits loosely into the sleeve, *G*, which bears against the rim. The sleeve is beaded on top to keep it cylindrical, and ⅛ inch below the top of the sleeve there is a thin annular disk of platinum, which is fused to the other part of the sleeve. The crucible, with this thin sleeve, is supported by a platinum wire triangle placed over a clay cylinder, and which, in its turn, is supported by a ring of a filter stand at a height suitable to the height of the burner. The clay cylinder is 3¼ inches high, with a hole 2 inches in diameter at the top, and tapering down to 1$\frac{3}{16}$ inches at 1 inch from the bottom, and from there down widening out again to 1½ inches (Fig. 6, left hand of hood). The sleeve prevents the crucible from slipping through, and from tilting over on the wire triangle or the holes in the desiccator. It also helps in heating it to the highest possible temperature for the full length, as it baffles the flame. This sleeve is also very convenient for lifting the crucible from the cylinder into the desiccator, and from thence into the scale pan, as the operator simply grasps the disk of the sleeve with an ordinary pair of forceps. It weighs 9 grams. We also use the same crucible and sleeve for fusions when making complete analyses of the ash.

Determination of Sulphur.—This is

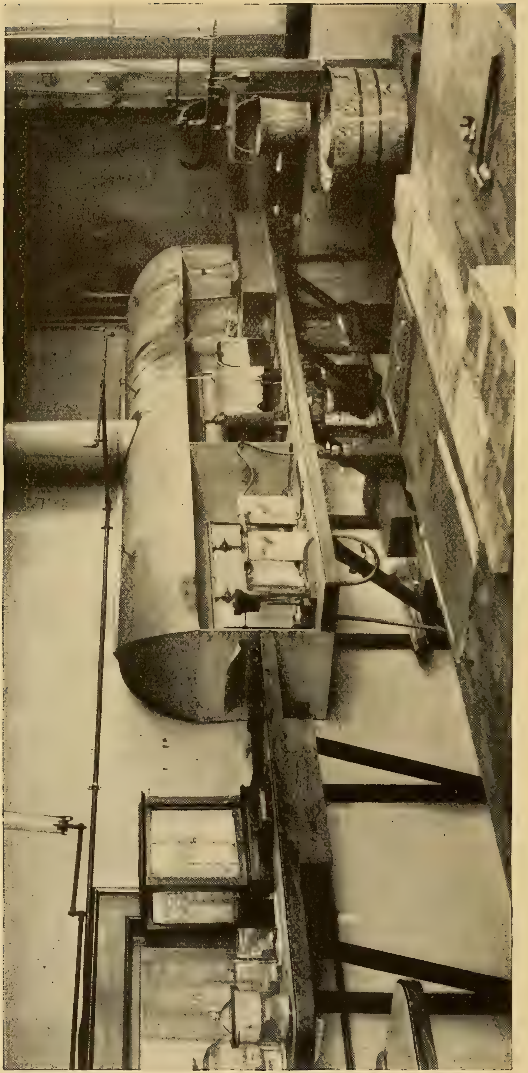


FIG. 6.—THE SPECIFIC GRAVITY APPARATUS.

done by Eschka's method,* with one exception; that is, we use a different form of crucible, in the shape of a light, small-lipped and wire-rimmed beaker of platinum, holding 100 cc., or about three times as much as the ones usually employed. It is $2\frac{1}{4}$ inches high, 2 inches in diameter, tapering slightly toward the bottom, and weighing 33 grams. By using a larger crucible all the operations of oxidation, acidulating, oxidizing with bromine, and driving off the excess of the latter, etc., can be performed without transferring or washing into a beaker, thus saving considerable time.

Analysis of the Ash.—This, of course, is a comparatively long operation, and is done by the ordinary method.

Rough Determination of Specific Gravity.—This, though a comparatively simple, and, to all appearances, rough, operation, promises to be of value to producers and users of anthracite coals. The apparatus we employ is constructed as follows: It consists of four parts:—an ordinary sheet-iron bucket, such as is used about the works for sand or ashes, and holding about 25 pounds; an ordinary wash-tub; a Fairbanks' market beam scale; and a cylindrical tin pan about 14 inches in diameter and 7 inches deep. The apparatus is shown on the right-hand side of the view of the laboratory, close to the window (Fig. 6). The weighing beam is attached to the post by means of a small crane, which throws it out from the post. The ordinary hook used for suspending material to be weighed carries a yoke from which the tin pan is suspended by two wires. The bucket is also hung on the same hook. The tub is then filled with water until the tin pan is covered, and the whole is then balanced by means of a weight hung on the outer end of the beam, which weight remains fixed. The poise used for weighing moves along the beam in the ordinary way. The beam is divided into pounds and quarter pounds, each notch representing one-quarter pound when the ordinary poise is used. In order to weigh to $\frac{1}{100}$ of a pound, a little rider is made of sheet metal and of such a weight that each notch represents $\frac{1}{100}$ of a pound, so that by placing the poise in the notch corresponding to the even pound which is just less than the actual weight, and then moving the rider until the beam balances, and reading off the number of notches, the actual weight in pounds and $\frac{1}{100}$ pounds is obtained. If, for example, the rider is in the second notch to the right-hand of the 10-pound notch, it would read $\frac{42}{100}$ pounds; that is, the 10 pounds would represent 40 notches, which with the other two would make 42. If it were at two notches to the right of 17 pounds, it would represent $\frac{70}{100}$ pounds, or 4 times 17 plus 2.

When the average specific gravity of a shipment of coal is to be determined, specimens are taken from all parts until a fair average sample is obtained. This is spread on a platform, and quartered down until the material is reduced to about 20 pounds, which is then freed from dust, dried in the apparatus shown in Fig. 3, and put into the bucket. It is not necessary to take any specific quantity,—simply a bucketful. The bucket is then hung on the hook and the weight of the coal obtained, everything else having already been counterbalanced. When this has been done, the coal is poured slowly from the bucket into the pan in the tub, and after being stirred so that all the air escapes (this is important), the weight in the water is taken; deducting from the weight of the coal in the air the weight of the coal in the water gives the weight of the water displaced; dividing the weight of the coal by the weight of the water displaced gives the specific gravity of the coal. Of course, the calculations are the same as in ordinary methods of determining the specific gravity, but the operation can be performed rapidly and with a large quantity of coal. There seems to be no doubt that there is a close relation between the specific gravity of coal and its percentage of ash. Mr. Walter R. Johnson, in his celebrated report upon American coals, suggests that there might be such a relation, but gives no figures to establish the fact. A careful study of a great number of analyses of coal and determinations of specific gravity has led us to believe that, although our experiments are not as yet absolutely conclusive, there is a strong probability that, for a given size of coal from the same colliery under ordinary circumstances, the determination of the specific gravity of an average sample will give very nearly the same percentage of ash as will be determined by analysis, although the relation may not be exactly the same for different mines or for different sizes of coal. If the specific gravity and percentage of ash, in any sample of coal below egg size, be known, the percentage of ash in any other sample of the same size coal, and from the same colliery, can be satisfactorily determined, we are inclined to think, from the specific gravity of that sample, by the formula

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* This method is described in the following periodicals: Rothe, *Mitheilungen Königlichen Technischen Versuchsanstalten*, 1891, page 107; *Stahl und Eisen*, Vol. XII., page 31.

F. Hundeshhagen, *Journal Analytical and Applied Chemistry*, Vol. VI., page 385; *Chemiker Zeitung*, Vol. XVII., page 454; *Engineering and Mining Journal*, LIV, page 320; *Berg und Huttenmannische Zeitung*, Vol. LII., page 141; *Journal Society of Chemical Industry*, Vol. XII., page 465; *Chemiker Zeitung*, Vol. XVI., page 1070.

$$y' = y + (x' - x) \times a$$

in which $x =$ the standard specific gravity, $y =$ the standard percentage of ash, $x' =$ the specific gravity of coal determined by our apparatus, $y' =$ the percentage of ash to be determined, $a =$ a constant for coal from same mine.

It is possible, however, that for the very smallest size from mines where the percentage of iron pyrites is large or very variable, the formula may require some modification. It might also fail if the character of the coal, slate, or other impurities varied very materially in the different veins or in the different parts of a mine, so that the product of the mine could not be considered a uniform one. There is no question, however, that the determination of the specific gravity in this rough way, which can be done by any careful person, is of great value, and would be a very good check on the shipments of coal received, provided it was accompanied from time to time by a slate determination by means of chloride of zinc, and occasionally by an ash determination by analysis. I do not wish to speak too positively on this subject, because we have not concluded our experiments, and hope later to give more information upon this point. In the Lehigh region, for any size of coal, we find that, within what may be called the commercial limit of purity, an increase of 0.01 in the specific gravity corresponds to about an increase of 1½ per cent. of ash; that is to say, that if coal of the specific gravity of 1.54 contained 8 per cent. of ash, the same size of coal from the same mine when its specific gravity was 1.56 would contain twice 1½ per cent. more ash, or 11 per cent.

Fig. 6 is from a photograph of one corner of the analytical room of the laboratory, and is given for the purpose of showing in how little space all the apparatus necessary to carry on the majority of the foregoing operations can be placed. On the extreme right is seen the apparatus for determining the specific gravity. On the left is placed a small but very excellent hood made of galvanized iron, with a ventilating pipe through the roof, in which the operations of determining moisture, sulphur, ash, and volatile combustible matter are carried on. Almost directly under the pipe is seen the beaker crucible for determining the sulphur, being supported on a sheet-iron frustum of a cone which protects the flame of the Bunsen burner inside. A little to the right of this is seen the drying oven; then comes, under the table, the tank of oxygen, with the hose conveying the oxygen gas to the incinerating dish. The first pair of firebricks, only one of which is seen, is where the incineration is completed with natural draft. The india-rubber hose passes over one of the bricks which supports the dish, and is protected from the heat by being wound with sheet asbestos. The two bricks in front show the apparatus in which the incineration is done with oxygen, and still further to the left is the apparatus for determining the volatile combustible matter. Of course, while there is nothing specially novel in the arrangement, it is very compact, and shows how little space is necessary for carrying on the work. The balance is placed close to the hood.

We have become so thoroughly impressed with the importance of having the specific gravity of all samples of coal which we analyze, that, whenever the sample sent to the laboratory is large enough, we obtain the specific gravity in the way given above or by means of a flask, and find that it adds very materially to the value of the data obtained by analysis. It seems to me that in all important boiler tests not only the coal used should be analyzed, and a special determination made of the amount of moisture in the coal when it is actually fired, but also that the ashes should be carefully analyzed. The sample for both the analyses should be obtained by quartering down all the coal to be used, and quartering down all the ashes made. I find in the reports of many boiler tests that only the name of the coal is given, such as Lehigh egg, Schuylkill stove, Wyoming pea, etc.; in some cases, perhaps, the name of the colliery may be added. Such information is not of very great value, as the quality and purity of these coals vary not only in the same region but in the same mine, from day to day, and anyone who wishes to get at the actual facts determined by the tests has not the information necessary to do it. Even if the amount of moisture and volatile combustible matter in the coal be known, the exact amount of carbon burned cannot be determined except by an analysis of the ash. If we know exactly how much coal is placed in the furnace, including what is left on the grate, and how much carbon there is in the ash, we can determine the exact amount of the carbon, originally in the coal, that has been consumed, less the small portion carried up the chimney with the fine ashes. I have found nearly 60 per cent. of carbon in ashes from some boilers; and in some of the boiler tests which have been reported to me not much over 60 per cent. of the carbon actually in the coal seems to have been burned.

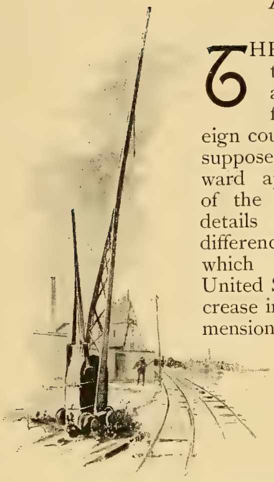
Under these circumstances it seems to me misleading to say that so much water has been evaporated per pound of combustible. In fact, it is of very little importance how much water can be evaporated under special circumstances with a pound of combustible. What the man who pays for the coal wants to know—and he is the one for whom the profession generally works—is how much water can be evaporated for $1 with different coals, and it is of no advantage to him to know that if he pays twice as much for his fuel he can evaporate 5 per cent. more water per pound of fuel, and get a wonderful theoretical evaporation from his boiler. It is the question of how much more you can get for $1 by using a certain coal, and to arrive at this result it is very important to know exactly what kind of fuel is being used, whether it burned up, and whether it was artificially dried before it was put into the furnace in the test.

There is another question of very great importance to users of coal, on which I am not, however, ready to say much: that is, the clinkering. It depends undoubtedly upon two points,—the temperature at which the coal burns, and the composition of the ash.

The fact that a coal does not clinker may be due to its impurity; that is to say, the coal may be so impure that it will not make a fire hot enough to melt the ash, although the composition of the ash may be such that were it contained in a pure coal it would melt easily. On the other hand, the coal may clinker because it is very pure and burns at a very high temperature. It is generally admitted that the more bases there are in the ash the more fusible it is likely to be. It seems probable, from information we have, although it is not very definite, that two coals, each of which burns without giving much trouble on account of the clinkering, may clinker more if they are mixed, the reason being that the composition of their joint ash is more fusible than that of either of the ashes separately.

AMERICAN AND FOREIGN LOCOMOTIVES.

By David L. Barnes, M. Am. Soc. M. E.



THE locomotives of the United States are not so different from those of foreign countries as might be supposed from the outward appearance; most of the differences are in details and result from differences in operation, which demand in the United States a large increase in the general dimensions. A rather lengthy paper on the subject was presented by the author at the International Engineering Congress, held at Chicago last year, and from this what follows has been taken, giving, in brief, the main considerations involved.

In studying distinctive features of locomotives of all countries, it is necessary to know in minute detail the conditions of operation under which each class of locomotives is worked, as it is generally found that engines everywhere are well adapted for the work they do. The main difference between locomotives used here and in other countries is a necessary result of the difference in environment. In other countries, generally speaking, the distances are short, competition small, wages low, and money rentals moderate; in some a governmental control removes all competition. In the United States, long train runs, high wages, sharp competition, and high rates of interest define the method of railroad operation so clearly that it is practically beyond the power of any individual company to vary much from the almost universal practice of running heavy trains. It is this necessary policy of heavy trainloads that gives rise to the wide difference which is found in maximum hauling power of the American and foreign locomotive. This increased power demands more weight for adhesion and greater steaming capacity; therefore, one finds the American engines heavier and the boilers larger for similar classes of work.

Many of us in the United States have thought that certain details that are universal here, such as the equalization of the weight between driving wheels, the four-wheeled swivelling and lateral motion truck, outside cylinders, the firebrick arch and iron tubes, etc., are not commonly used in other countries, and formerly they were not; but now equalizers are common in England, they are standard in Germany, common in France and in other European countries. Outside cylinders are quite universally used in Germany, are common in England, and frequently used in France, Italy, and other countries. Fire-brick arches, iron and steel tubes, and lateral motion swiveling trucks are quite common, although not the rule everywhere, so that in looking for such general features of design of locomotive details as are peculiar to the United States, one finds at the present time but little besides steel fire-boxes, bar frames, cast-iron wheel centres, and tenders with swiveling trucks. There are many peculiarities in minor details, but these do not affect in any material way the economical operations of the engines.

The use of cabs is dependent, not upon the country, but upon the climate, and cabs are generally found where the winters are severe. As a rule, all differences in the designs of details can be traced directly to the relative prices of labor. Where labor is high, designs are simple; duplication and interchangeability over-rule minor features of durability and efficiency, and in general, cast pieces are used instead of wrought. For instance, in the United States the duplication of parts receives more attention than in foreign countries, and it is common to use a clumsy, heavy cast-iron piston, that requires less hand labor than the foreign type of piston—the Swedish—which is one of forged steel, very light and strong. Also driving wheel centres are here made of hard cast iron, while in Europe they are almost universally made of wrought iron.

We are all more interested in such features of locomotive construction as affect the operation than we are in the parts which affect the cost of repairs, for the reason that the other costs of locomotive service are the major part of the total and greatly exceed the repairs. Again, the cost of repairs is so dependent upon the facilities and the price of labor that it is impossible to learn much about the relative merits of designs from a study of the cost of repairs in different countries. Facility for making repairs is the all-important factor of repair costs. Take, for instance, the renewal of driving tires. In this country it was formerly the custom to take an engine into the shop for repairs whenever the driving tires needed turning; in this way the repairs of locomotives were largely dependent upon the durability of the tires. Now this has entirely changed, and in the most advanced shops general repairs are made only when they are needed. A locomotive may come into the shop in the morning with bad tires and axles, and be sent out again at noon with a new set of wheels complete or a new set of tires put on ready for use. The improvements in handling heavy parts and in other facilities for making repairs have materially reduced the cost of keeping up locomotives, so that it is impossible to say what are the advantages of those details of construction which are more common in the United States, without knowing the comparative facilities for making repairs; and, furthermore, the difference in the condition on different roads in any one country, in the United States, for instance, is great enough to give entirely different results in the cost of locomotive repairs per mile run.

Lack of accurate information has led to considerable discussion within the past two years about the mileage of locomotives before being sent in for "general repairs;" but there is no accuracy in comparison in matters of this kind between locomotives used in different countries, as the conditions are so different. It is not to be expected that a locomotive hauling heavy trains can run so long without a general overhauling as with comparatively light trains. However, it is not the weight of train that governs the mileage made before "general repairs." The term "general repairs" is indefinite, and some roads keep up the majority of the so called "general repairs" without taking the locomotives into the shop, while on the other roads some of the "running repairs" are classed as "general repairs," owing to the lack of facilities which compels the locomotive to be considerably dismantled before the parts needing repairs can be made accessible.

It is not within the scope of this paper to say much about different methods of operating locomotives, but operation so controls designs that one must be understood if the reasons for the other are to be comprehended. The dispute about the economy of running heavy trains has arisen almost solely on account of a lack of definite information on the subject. One may safely grant that if there was any defect in the policy of heavy loads, the exceedingly sharp competition in the United States would have long ago developed the defects, and we should now find some of our roads hauling light trains at frequent intervals. To the contrary, the practice of heavy train-loads is universal here. The average weight of a foreign freight train, exclusive of engine and tender, is approximately 450 tons. Trains are much heavier on the Continent of Europe than in Great Britain. The average weight of an American freight train for level roads is not far from 1350 tons. In the appended table the coal used per ton-mile of total train is taken as a constant for all weights of train. This is only approximately correct, but it is quite near enough for the comparison now being made, as the coal per ton-mile of total train does not vary much with different trainloads when the power of the locomotives is in proportion to the train. The coal per ton-mile of total train is taken as .1275 lb. This corresponds with good practice in the United States. The wages of train crews in this country, on any one road, are nearly the same for all trains.

Table of Engine and Train Weights and Costs of Haulage.

No. of cars.	Weight of cars.	Weight of locomotive and tender.	Engine crew wages per mile run.	Train crew wages per mile run.	Coal used per ton mile of total train.	Oil, waste and repairs for locomotives per mile run
	Tons.	Tons.	Cents.	Cents.	Pounds.	Cents.
10	450	70	5.33	7.25	.1275	3.62
15	675	75	5.33	7.25	.1275	3.62
25	1,125	85	5.33	7.25	.1275	3.62
50	2,250	95	5.33	9.25	.1275	3.62

The cost per useful ton-mile for train wages is, in general, the controlling element here, and it decreases as the trainloads are increased. In the fuel account there is a saving from heavy trainloads up to the point where the engine is excessively overloaded. This is frequently observed from tests of locomotives. Take the case of two locomotives and give one a heavy and another a light train; the one with a heavy train will use more coal per mile, but there is a greater useful load in proportion to the dead load of locomotive and tender, and the resultant coal per useful ton-mile is less with the heavy train than with the light train. This reduction in cost of transporting useful loads goes on, even after the load is increased, to a point where the scientific steam engineer would deem the locomotive to be too much overloaded for the economical use of steam. So much bearing does the environment of condition and cost of wages have on the policy of locomotive operation that in the extreme cases where fuel is less than one dollar per ton the most economical trainload is the maximum load that can be hauled by one engine almost regardless of the economy with which the steam is used. So, then, in the United States, heavy trains, high wages, sharp competition and high rates of interest fix the main distinctive feature of American locomotive practice, which is the greater hauling power of the locomotives. The greater power is obtained in two ways—first, by using locomotives of greater weight; and secondly, by forcing the boilers to a degree almost unknown elsewhere.

Outside of the greater hauling power, which necessarily requires greater weight and larger parts, and the forcing of the boilers and the machinery, which increases the wear and tear, there is not so much difference in locomotive practice here and in other countries as is generally supposed. From the external appearance of locomotives of different countries, one is led to expect important differences in the vital parts of construction. Thus the smoothly-encased European locomotive, with a weather shield instead of a cab, often appears to be quite a different machine from the American locomotive, with its structural parts exposed to view, and with a small house on the top of the boiler; yet the organic differences are really small. Each has a pair of single-expansion steam cylinders, either inside or outside of the frames, to which the steam is admitted, and from it allowed to escape by a single plain slide valve actuated by a link motion and eccentrics. The boilers are both internally fired and have approximately the same arrangement of tubes and parts. The frame construction in both consists of two horizontal and longitudinal beams, made either of bars or plates. The guiding and carrying trucks are perhaps more generally used in the United States, but not to an extent that would justify the claim that a swiveling truck is a distinctive feature of American locomotive practice. Carrying trucks have sometimes two wheels, and again four wheels. Sometimes they swivel, and in addition swing laterally. Where they do not swivel or swing laterally, considerable end play is allowed in the bearings, which gives them, to a considerable extent, the equivalent of a lateral motion. Many engines in the United States are without lateral motion in the truck, and in Europe one finds many trucks that both swivel and move laterally.

The drivers and connecting-rods of locomotives of all countries are alike in all functions ; and so on, throughout the principal details, there is but little in the general purposes of construction that can be considered distinctive differences, or differences that should materially affect the economy of operation under the same conditions. However, few as are the important differences in general features, yet there are many and great differences in detail when viewed from the standpoint of the experienced locomotive builder. These differences do not affect the economy of operation, but govern somewhat the durability and affect mainly the amount of labor required in construction, and thereby influence the first cost.

The important distinctive features of American locomotive practice are : Large dimensions, great hauling power, duplication of parts, steel fire-boxes, bar frames, the universal use of equalizers for all types, and cast-iron driving wheel centres ; these are manifest advantages from an American standpoint ; also, as distinctive features and of questionable advantage, are tenders with swiveling trucks, and small drivers for high speeds. A distinctive feature and a decided disadvantage are the use of heavy reciprocating parts.

The locomotives used in foreign countries are now, generally speaking, of about the same weight and power as those used here ten years ago, and the heaviest foreign types for passenger service are of about the same weight as our light eight-wheel type. There are none used elsewhere on comparatively level roads that are as powerful as our ten-wheel and Mogul express engines. Abroad there are many and varied types of locomotives, and abrupt changes in construction are more common than in the United States. So varied are the plans followed, and so rapidly do the changes in important details take place, that the onlooker receives the impression that a general dissatisfaction exists. Recent developments have followed American plans, both in weight and type, in a way that is complimentary, and there is some evidence that when foreign locomotive designs become more constant, and the process of selection evolves a nearly universal set of types, some of the features that are now distinctively American will find a place in the ultimate plan. One distinctive feature of the American locomotive construction that will eventually become universal is the steel fire-box. The policy of hauling heavy trains, which is another distinctive feature of American practice, is so clearly advantageous that sooner or later all countries having long distances and competition between common carriers will run heavy trains, and will construct ponderous locomotives to haul them.

THE ENGINEER AS AN EXPERT WITNESS.

By M. M. Tidd, C. E.

THE relation of the engineer to those with whom he comes in professional contact was made the subject of a series of papers read before the Boston Society of Civil Engineers early last year and reprinted shortly after in the Journal of the Association of Engineering Societies. In one of these papers, dealing particularly with the engineer as an expert witness, the author took occasion to point out that one of the most delicate and perhaps disagreeable duties that an engineer is called upon to perform is that of such a witness. He is employed by one side of the case, and is expected to testify in such a manner as to give the greatest benefit to the case of his client, while the experts on the other side are expected to do the same for their side of the case. Thus we have the spectacle of two sets of engineers of equal standing and ability testifying in the same case, each endeavoring to controvert the testimony of the other. Should either not succeed in doing so, his client complains, and in many cases objects to the bill. The natural result of such a condition is to bring the profession into disrepute. Some of the testimony in cases that have come under the author's observation has been enough to bring contempt upon even a lawyer's profession.

The author has in mind a case which may serve as an illustration. It was a case where a suit was brought by the owners of a mill against a town which had supplied itself with water taken from one of the sources of the stream from which the mill obtained its power, or at least a portion of it. As the water power was unreliable, the mill was supplied with steam power enough to run it entirely, and at the time of the trial of the case it was doing so. It was proposed by the defendant to make restitution by a sum of money which would replace by steam the power lost by the diversion of the water. The plaintiff claimed that a complete plant to furnish that amount (about 7 horse-power), an engine, boiler, power-house and the salary of a man to run it, should be paid for. The defendant demurred and claimed that it should simply pay for the coal used in the present plant to give the 7 horse-power required. The plaintiff on oath declared that his engine was taxed to its utmost capacity to run the mill, and that it was impossible to get another horse-power out of it.

At this point the court adjourned for two days, and the experts for the defendant, never having seen a mill run up to its utmost limit, visited it the next day. There was one main shaft running the entire length of the building, at one end of which were permanently connected three 30-horse-power turbine wheels, standing in about 8 feet of dead water, while at the other was connected a steam engine running very finely, driving the entire mill and the three turbines. This was certainly a rich find for the experts. Upon interviewing the engineer the following dialogue took place:

"You have a good engine there?" "Yes, first-class." "Runs the mill very easily?" "Oh! yes." "How much more power could you get out of it if necessary?" "Oh, well, 10 to 15 horse-power." "Do you always carry the three water-wheels when you run the mill?" "Yes, there is no means of disconnecting them." "How much power do you suppose you are wasting on them?" "Well, probably 50 or 60 horse-power."

Now this was the steam plant which the plaintiff testified could not turn out another horse-power. It is needless to say that this engineer was invited to testify at the next session of the court, which he did honestly. The author merely quotes this as one instance of the many that have come under his observation where such reckless testimony is indulged in. Such testimony is certainly no credit to the profession.

There is another disagreeable point in this portion of an engineer's profession in that he is often called upon to testify before a stupid jury or a commission, members of which are equally stupid. The author remembers testifying in a case before a commission of three lawyers. The hearing was continued for 22 days. There were seven engineers in the case and each one was required to give a statement of what constituted a nominal horse-power, which each one did very clearly and carefully, all agreeing in every detail. You can perhaps imagine their disgust when on the opening of the twenty-second day's session one of the commissioners stated that he had used his best ability during the hearing to comprehend the merits of the case but so far he was totally unable to understand what a horse-power was ! ! ! Such a case as this can hardly give an engineer much respect for commissioners, or satisfaction in testifying before them.

It seems to the author that an engineer should have a clear understanding with his client as to the merits of the case, and as to what he expected to testify to, before he agrees to enter the case. He should not regard a case entirely from the standpoint of how much money he is to get out of it. He cannot afford to sell his reputation at any price. The author remembers a case where he was asked to testify, but upon investigating it he was satisfied that the party had no case, and distinctly so informed the counsel, who replied that that was his business and he could not understand why the author would not enter the case if he was willing to pay him for it. The author could only reply that he could not take his client's money unless he could render him a service equivalent to it. In this case the author's answer to the first question would have been fatal to his case ; therefore he could not testify for any price.

There is another difficulty in this portion of an engineer's business that is exceedingly disagreeable, namely, the uncertainty as to when he will be called upon to testify. He gets his figures all ready and after much study gets the case clearly in his head and is notified that he will be called upon the stand to-morrow morning ; he makes all his arrangements accordingly. When he appears at the hearing he is informed that the case is postponed for a month. When that time arrives he has forgotten his testimony and must read up anew. The author thinks that the whole matter of doing that business is wrong. The experts should be called by the court, and the expense assessed as in the case of any other "costs." In that case the expert would feel under no obligation to either party and would have no client but the court.

ELECTRIC CANAL BOAT PROPULSION.

By Joseph Sachs, M. Am. Inst. El. Engrs.

LECTURING recently before the New York Electrical Society on electric canal boat propulsion, with special reference to the much-talked-of Erie Canal enterprise, the author pointed out that while electricity had been suggested at various times as a source of energy for the propulsion of such boats, it had never been brought to such a degree of prominence as during the last two or three years.

The method, as generally proposed, and which was tried on the Erie Canal, near Rochester, during the latter part of 1893, consists in placing an electric motor upon the canal boat which revolves a screw propeller at the stern. This electric motor receives its current from suitable overhead wires through a flexible contact arrangement. There certainly is no doubt in regard to the successful mechanical operation of such a combination, but this method is not the only, and certainly not the most feasible and economical, plan of operating canal boats.

There are in fact five other methods (six with propeller) of propelling boats in shallow and narrow bodies of water. They may be divided as follows: 1. Propellers. 2. Flexible submerged cable towing system (similar to European methods). 3. Rigid rail towing or hauling (exterior). 4. Rigid rail towing or hauling (submerged). 5. Movable cable. 6. Motor locomotive haulage.

The requirements for the successful system may be enumerated as follows: It is particularly necessary to deepen the Erie Canal, as with the present depth of hardly seven feet, the present maximum speed of two and a half miles per hour can hardly be maintained. The method of propulsion must not injure the canal structure. It should appeal to the boatman as a better and cheaper method. The chance of breakdown of propelling machinery should be reduced to a minimum. It should enable the present methods of propulsion to be continued. Any structure erected should be strong and not easily disabled. The system should require as little machinery as possible upon the canal boat. The source of current supply should be constant.

While the propeller method would include all boat propellers, such as paddle wheel, jet or screw, it has been found that the screw is the most feasible. There are three methods of applying the screw to canal boat propulsion. 1. By placing the motor and screw directly upon the canal boat. 2. By the use of separate propelling tugs that carry no freight. 3. By the use of a false or detachable stern which holds the motor and screw. With any of the above methods it is necessary to have some source of current supply. The most generally proposed and practical method consists in suspending a wire or wires over the canal. As the canal cannot be used as a return circuit two wires are necessary for boats going in each direction (four wires for both). Arrangements must also be made to permit the boat to move laterally, and therefore some form of flexible trolley carriage must be used. The most feasible plan of applying the screw will be some form of separate tug or false stern, as by such arrangement various objections to placing the motor directly on the boat are obviated. Such methods will also be somewhat more efficient.

Objections to any propeller methods are: 1. Low efficiency of screw propulsion and large operating expense. 2. Equipment of boats with motors. 3. Injury to structure by wash. The effective energy to move a certain boat at a certain speed through a body of water is the same, no matter how the boat is propelled. The method of accomplishing this with the least loss above the effective power necessary is certainly the most efficient. In some sort of direct pulling or hauling system this loss will certainly be less than with the screw.

The submerged cable method of propulsion consists in laying at the bottom of the canal a chain or cable, which is raised and passed over rollers or friction drums on the propelling or towing boat. These drums firmly grasp the cable or chain, and by rotating, pull the boat along the canal. This system is extensively used in Europe. A separate towing boat is used with suitable engine and boiler and the machinery necessary to pull on the cable or chain. In 1875 such a system was tried on the Erie Canal, but was found to be unsuccessful. The electric motor can readily be substituted for the engine and boiler in such systems, and current can be supplied, in a similar fashion to that used in the previous method. Instead of using two wires, one only would be necessary for each direction, as the cable could be used as the return. As the motor takes up much less room than the engine and boiler, a separate towing boat would perhaps not be necessary as in the European systems, but the motor and machinery could either be placed directly on the boat or upon a detachable platform, as suggested by a German engineer. Such methods would not be successful on the Erie Canal. Suffice to say that it has been tried and found wanting. The principal objections are the slipping of the chain or cable, the large amount of slack chain each boat must take up, and the necessity of dropping and taking up the cable a great number of times, caused by the many locks.

In the method of pulling on a rigid rail or rack adjacent to the canal and parallel to it, a motor is placed on the boat and rotates suitable rollers or pinions which engage the rail or rack and extend from the boat upon arms. The current is furnished by similar means to those in the previous cable methods, but the lateral movement of the boat is obviated. The structure supporting the rail also supports the wire. Such a method is quite practical, but also has some of the objections of the former cable method. The efficiency of the two are very nearly alike.

The method of pulling on a rigid submerged rail is the reverse of the above. Instead of placing the rail adjacent to the waterway it is laid at the bottom of the canal. A motor is placed on the propelling boat and rotates the roller engaging the rail or rack. The shaft to which the rollers are attached extends through the bottom of the boat. In such methods it is necessary to have a separate propelling boat. A single contact wire arrangement can be used as in either of the previous rail or cable methods. Such a method would no doubt operate mechanically, but would be very costly and no more efficient than any of the previous pulling methods.

The moving cable method is similar to the operation of an ordinary cable road, with the difference that instead of the cable pulling cars it is connected with the canal boats. The general plan would be to generate electricity in one or two very large central generating stations where water power could be procured and distributed at high pressure to electric cable operating stations located along the route of the canal. Here large electric motors would operate the cable machinery and move the cable. An arm would extend from the boat to the moving cable, and by use of suitable gripping devices the boat would be pulled along. The boat would actually be moved wholly mechanically, but the system, as a whole, would be an electric method. The various losses in the many transformations of energy, the operation of the long cable, the many cable power plants necessary and the extremely large cost and complicated mechanism would appear to make this method somewhat impractical.

The motor locomotive haulage method is really an elaboration of the old and primitive mule method, but instead of the slow and uneconomical animal a more rapid, efficient, electro-mechanical mule is substituted. The method consists in running an electric motor parallel to the canal upon a suitable structure or track and receiving current from contact wires adjacent thereto.

This motor locomotive is connected with the boat by suitable means and hauls it by being propelled along the track or structure. Such electric locomotives may be large and heavy, be controlled by a motorman and haul a train of boats necessitating a large, heavy and strong structure of track; or they may be small and run upon a light structure, each motor being attached to a single boat and the motor on the structure regulated from the boat. The first method would necessitate the location of tracks on each side of the canal, and would interfere with the present methods and be very costly and perhaps somewhat impractical.

In following the latter method, a light, strong structure can be erected along the canal in such manner as not to interfere with the present methods. Upon this support, small electric motors are adapted to be propelled in either direction by a current received from wires supported on the structure. The boat in the canal is connected with the motor by a tow line, and the motor is started, stopped and regulated from the boat. Although the boats may be coupled, each boat is pulled by a separate motor, thereby permitting the erection of a light, small structure only strong enough to stand the strain of one boat. All the motors are regulated from one source on the first boat. The motors for both directions may be operated on one or both banks of the canal or suspended overhead. The main features of such a method are: 1. The boats are not changed. 2. Any other method may also be used. 3. Economy of operation. 4. No damage to canal structure. 5. No machinery on boat. 6. Chance of being stalled reduced to a minimum.

The method of haulage last described is certainly very feasible, and perhaps the most practical of the various haulage systems described. As compared with a screw propeller method it is very much more efficient and has none of its disadvantages. A saving of over 15 per cent. can be shown over the operation of the propeller method. This is taking into consideration the cost of plant, interest, coal, maintenance, labor, etc. To operate 600 boats constantly moving on the Erie Canal (300 going each way), at three miles per hour in eight feet of water, and allowing a constant operation at this rate for 220 days, the trolley propeller plant would cost $4,500,000, and operating expenses would amount to about $800,000 for that period. To operate the same number of boats by the hauling method the first cost of plant would be $5,550,000 and cost of operation about $680,000. These figures are merely a rough approximation. It is assumed that generating plants are erected along the route of the canal at distances apart of about twenty miles, distributing each way, and that steam is used as a prime mover.

If the electric propelling system is installed and maintained by the State, and we do not consider interest on plant, a much greater saving can be shown in favor of the hauling method. With a properly installed plant, on this basis, from 30 to 50 per cent. can be saved over the present steam method. It will be seen that although the first cost is greater in the latter method the operation of boats per boat mile would be less. Aside from this fact, however, the latter method has so many advantages over the propeller that some form thereof will no doubt be the future method of operating canal boats.

ELECTRIC CONDUIT RAILROADS.*

By Albert Stetson.

ELECTRIC traction for street railways has come to stay, and we must choose between the trolley, secondary battery and a conduit construction, either slotted or closed. The trolley has been, and still is, the most important factor in electric traction. But the structure is unsightly, and the poles and wires are a constant menace to the public. A trolley current will not, probably, kill a man who has no organic disease, but it will kill an animal, it will terribly burn anyone who comes in contact with it, and would probably cause the death of a man troubled with heart disease. The feed wires are a constant source of danger. A trolley wire may get crossed with an electric light wire carrying an arc current, and it then becomes a dangerous thing. If the streets are at all wide, very large poles, taking up too much sidewalk space, are used, and these invade public rights.

Secondary batteries have been used in nearly every large city of the civilized world, to supply the demands for electric traction, but have been given up as too costly. In large cities, the cable is a real rival of electric traction, and in many places has proved commercially successful. But there are some things that may give the electrician hope. The cable roads of St. Louis have, to a very great extent, given up their cable and are using the trolley. City railroads in the future will, no doubt, be electric, and it is questionable whether any more cable roads will be built. The cost of the powerful machinery required, the wear and tear upon the cable and the grip, the large amount of real estate required for their buildings constitute serious "first charges" upon the earnings of cable companies, and confine their operations to very large cities where traffic is enormous. Electric traction demands only a portion of the expense necessary for a cable road, and capital is seeking this method for investment. There is one other class that may be mentioned in passing, in which mechanical motors are employed on the separate cars. Many different motors have been proposed, such as carbonic acid gas, ammonia, gas engines, hydraulic motors, and compressed air. None of these have, to my knowledge, demonstrated their commercial utility, though I think the future outlook in this direction is promising. Some years ago I rode over the road from Vincennes to Paris, on a line operated by the Mekarski compressed air system. Its operation was all that could be desired from a spectator's standpoint, but I mistrust it had the same trouble as many others; good enough to spend money on for experiments, but unprofitable from a financial point of view.

We now come to a consideration of conduit roads, their excellencies and their defects. For years, electricians have worked to develop a practicable conduit system of electric railway, and many attempts have come near to success. The most extensive and, until recently, the most successful was the Bentley–Knight system. An immense amount of money was spent, the best talent was employed, and extensive lines were built at Cleveland and Allegheny City. Experiments were made in New York and Boston, and with the withdrawal from the field of the Bentley-Knight system, disappeared the last hope of our being able to place bare wires in a slotted conduit exposed to the severe conditions of our American climate. There is not a city in America to-day where a bare conductor laid in a conduit can earn a dividend on the capital invested. No matter what the system may be, no matter how carefully the insulators may be protected, unless the conduit is made air-tight and water-tight, which, of course, no slotted conduit can be, mud and dirt will get into the conduit and settle on the conductors. Leakage takes place from a conductor in proportion to the length exposed, and glass, porcelain, ebonite or any other of the so-called insulators, when covered with dirt, conduct the current as well as a similar layer of dirt elsewhere would do.

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* From a paper recently read before the American Institute of Electrical Engineers.

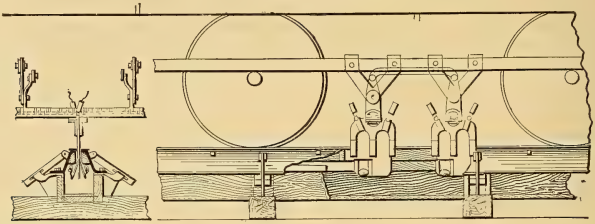


FIG. 1.—THE BENTLEY-KNIGHT TRUCK EQUIPMENTS, CONDUIT AND PLOW.

Mr. F. L. Pope says, in speaking of conduit experiments: "Hundreds of patents have been taken out and more than a million dollars have been disbursed in paying for tuition in the costly school of experience. More than once, and in more than one direction, success has at times seemed almost certain; yet the truth compels me to say that from the hard practical standpoint of dollars and cents, by which every invention must first or last be tried, the net outcome of all this vast expenditure of labor, time and money has, up to the present moment, been almost insignificant. The reward which awaits the fortunate person who succeeds in completely solving this problem, may well be regarded as a potentiality of wealth beyond the dreams of avarice. The problem of the underground circuit does not at first sight appear to be a very difficult one. It renders necessary, in the first place, a construction which will effectually resist the action of forces tending to disturb the condition of the wires, and with the heavy traffic on the streets this involves a very strong structure. It is absolutely necessary that the conductors shall remain insulated from each other and from the ground under all conditions of weather.

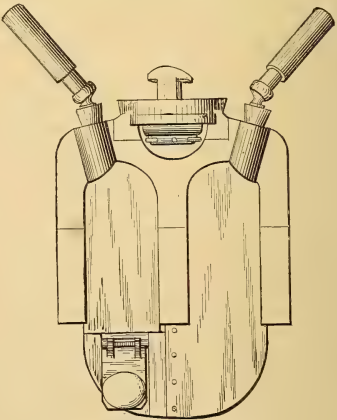


FIG. 2.—THE CONTACT PLOW.

The exigencies of heavy rains and snows necessitate a construction which shall permit of a thorough insulation of the conductors and a drainage of the entire system. There are other minor points which require to be taken into consideration. Without going into details, it is sufficient to say that the conduit system has been tried on an extensive scale in Denver, Cleveland and Boston, and to a lesser extent in several other places, but in every place the continual interference consequent upon its use has exhausted the patience of a traveling public and compelled its abandonment.''

In the Bentley–Knight system already mentioned, there is a conduit between the rails, provided with a slot, through which passes a brush for making contact with the bare wires laid in the conduit. They use a constant potential, about 500 volts being the normal voltage. The current strength is about 7.5 ampères, and the motor used will stand 60 ampères for half an hour. The electrical equipment is mounted on the truck, entirely independent of the car body, and the car is started and controlled precisely as the trolley car is. The contact plow consists of a flat frame hung from the car by transverse guides, on which it is free to slide the whole width of the car, and extending thence down through the slot of the conduit. It is provided with a swivel joint, so as to adjust itself to all inequalities of road or conduit. The frame carries two flat insulated conductor cores, to the lower ends of which are attached, by a spring hinge, small contact shoes of chilled cast-iron that slide along in contact with the two main conductors. At the upper ends are attached flexible connections to prevent flashing at the contact. To prevent the water, coming in through the slot, from causing a leak from the conductor to the metallic conduit, the insulator is provided with a water-shed flange at its base, which is preferably curved outward on the form of a saucer, though any suitably shaped flange may be employed, and the insulator extends out horizontally from the conduit, so that the flange occupies an upright position. The Bentley–Knight conduit system was the harbinger of better things. Splendidly constructed and well managed, but working on the wrong principle, it stands to the commercially practicable conduit road of the present and future in about the relation of the telephone of Philip Reis to the finished product of Professor Bell's genius. Of the Love system, now working in Washington, I have not been able to get any accurate or reliable information.

At Buda–Pesth, in Hungary, is the only conduit road employing a bare conductor that has ever achieved measurable commercial success. Mr. Hering in his book on ''Recent Progress in Electric Railways,'' says of it: ''The conduit is placed under one rail. It consists of castings having flanges of 7 inches placed about 40 feet apart, the space between being a conduit of concrete. The oval shaped conduit has a width, clear, of about 11 inches and a height of 13 inches. The slot consists of two beam rails having no inside lower flange, and fastened to the conduit frames by wrought-iron angle pieces. The width of the slot is about $1\frac{5}{16}$ inches and the total depth of the foundation below the rail top is about 27½ inches. The conductors, both positive and negative, are made of angle irons, secured by means of insulation fastened to the castings. They are sufficiently high above the floor of the conduit to be protected from the water which may collect in the conduits.

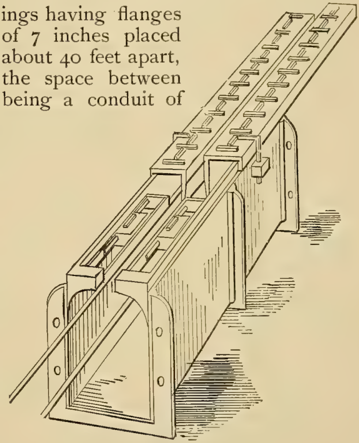


FIG. 3.—THE LOVE CONDUIT.

They are, furthermore, under the top of the oval, so that they cannot be touched from the outside. It should be noticed that there is no earth return used with this system, as both leads are insulated. The water which runs into the conduits is collected at the lowest points, and passes through settling boxes to the sewers. The second track may be of any desirable form, even only a flat rail. An objection to having the conduit under one rail instead of in the middle arises in cases where, by the nature of the course of the track and the curves, the cars become reversed in their positions on the track; such cases can probably be avoided by proper laying out of the road, and in the worst case by a second conduit under the outer rail for parts where it cannot be avoided. On a one-track line the cars must have their front and back platforms alike, as they cannot be turned around.''

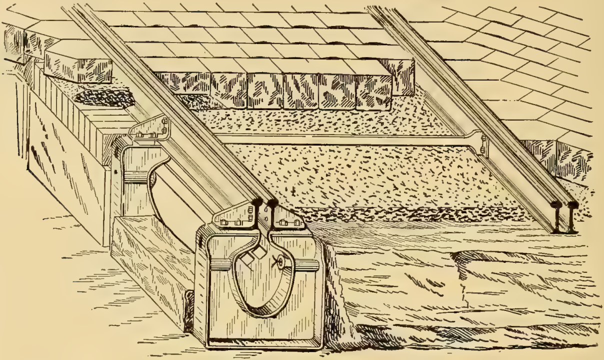


FIG. 4.—THE BUDA-PESTH CONDUIT.

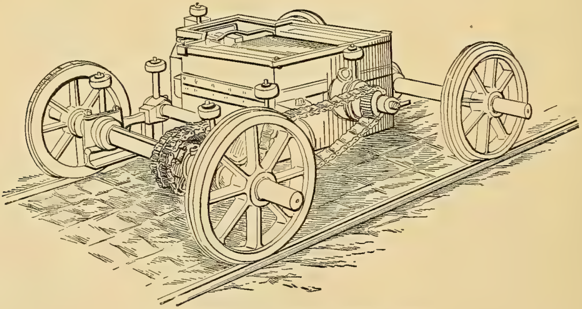


FIG. 5.—THE BUDA-PESTH MOTOR TRUCK.

The width of the slot is greater than could be allowed in any American city, since it would let into the conduit and wrench the wheels off two-thirds of our carriages. The slot must have that width since one of the slot-rails is used as a rail for the wheels of the car and the slot must, therefore, give room for the flange of the car wheel. The Buda–Pesth record is certainly remarkable, standing alone as successful among all the failures that have attended conduit experiments. It has not, however, been all plain sailing, and they have had some interruptions in their traffic. What success has attended the road has been due to several causes, first of all coming the excellent workmanship that goes with everything done by the world-renowned firm of Siemens & Halske. Next come the beautiful streets of Buda–Pesth, second to none. Labor is very cheap there; large numbers of men can be employed to keep the streets clean and the conduit clear, while our dear American labor would make operating expenses tell a sad tale. Third, an equable climate, enjoyed in none of our cities. Snow seldom falls there, and the rainfall is not great. Such a state of affairs, so many favorable conditions, would be found nowhere in America, and until they are found combined, there is no good reason for thinking that the Siemens & Halske system, employing the same bare conductor and the same construction that has failed here, would do any more than add one more wreck on the shore of conduit ventures. You must remove that bare conductor from the conduit, change the climatic conditions of our country, change the laws of nature and of electricity, or you cannot have a commercially practicable conduit system of that type. We must have a system that does not require us to change our streets and our climate, but that will take the rough-and-tumble conditions as they exist in all our towns, overcome all climatic difficulties, pay no attention to flooded conduits and poor drainage, and work summer or winter. If a road has a grade, and a heavy shower suddenly comes up, the water will collect in the hollows faster than any practicable drainage system can carry it away, and the successful road must work right along, undisturbed by such trifles. Any bare wire laid in a conduit, call the system by whatever name you will, must inevitably break down under such conditions. But an electric system, like any other traction system, should never break down, more especially in bad weather, when the public most need traveling accommodations.

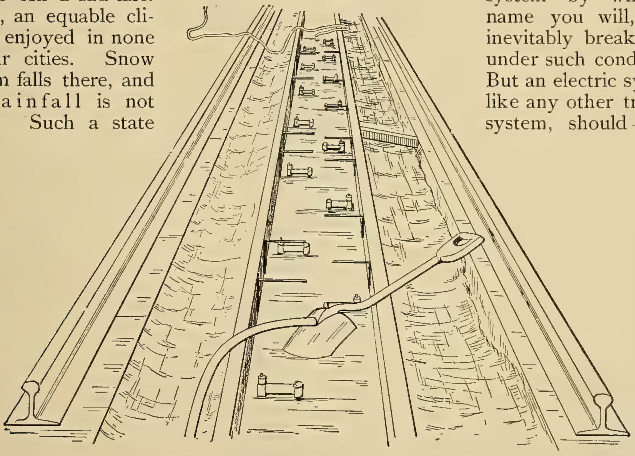


FIG. 6.—THE MUD TEST.

The idea of a closed conduit has had charms for many inventors, and much midnight oil has been consumed over this problem. The same difficulty is met with in all of them, viz., the continuous grounding of the live wire. Where magnets are used to switch in short sections of the line, they have proved a constant source of trouble. Among those who have worked in this field may be mentioned Pollak, Lineff, Gordon, Wheless, Schuckert, Edison and Van Depoele. Their systems all have very much in common, and the fundamental ideas are the same.

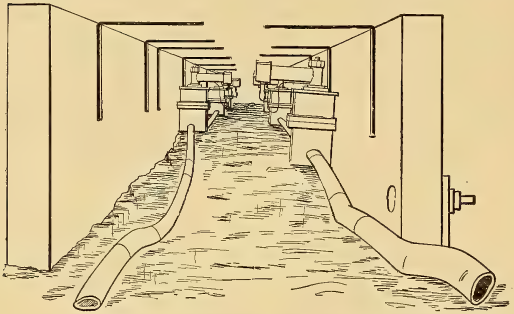


FIG. 7.—THE CONDUIT, SHOWING CABLES AND BOXES.

In the Gordon and the Lineff systems a small conduit, two or three inches square, is closed at the top by an iron cover laid in concrete, and this iron top serves as the current conductor. It is divided up into short lengths, about one-third the length of the car, and these sections are successively alive as the car passes along, and are cut out of circuit when the car has passed. In the Pollak system there is a middle contact rail in short insulated sections. The conductor carrying the current lies directly beneath this rail, and by means of flexible contacts momentary connections are made from it to that particular section over which the car is at that moment. These temporary connections are made by the aid of a magnet on the bottom of the car, which, in passing, attracts iron blocks under the rails, making contact with that section. Schuckert proposes a modification of this by having iron filings, when influenced by a magnet carried on the car, bridge over the space between the main and the sectional rail. The holes containing the iron filings were made widest at the bottom, and it was claimed that the sparking would do no harm, as the filings always present plenty of new surfaces of contact. This system is not in practical operation anywhere.

All will remember the announcement some time ago that Mr. Edison had invented a new system of electric traction. The overhead system, we are told, was to be entirely dispensed with, cars, trucks, tracks and roadbed, such as are now in use, were to be retained, certain changes being made in the joints and cross-ties. The power, furnished by 1000 volt generators, was to be distributed to reducing apparatus placed in boiler plate manholes at intervals varying in accordance with the number of cars required to be operated. At various reducing points the current was to be transformed from 1000 volts to a pressure of 20 volts, and put in direct communication with the tracks. This limit of 20 volts was fixed in order to prevent horses from being affected by the current. The chances are that the road has reached its full growth, and will never extend beyond Mr. Edison's laboratory.

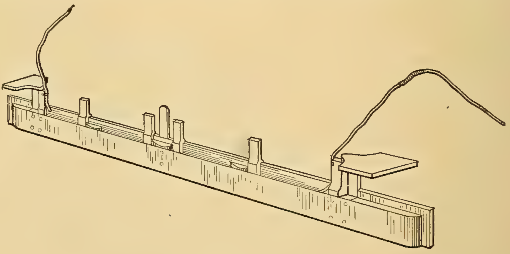


FIG. 8.—THE SHOE.

Mr. Van Depoele proposed a conduit closed by flexible walls. When the shoe passed, the slot was to be pushed open, and the elasticity of the sides of the slot was to close the opening when the car had passed. Such makeshifts, however, will not do. We must work with our streets as we find them. The operative device must be simple and of few parts, and we must keep carefully in mind that a conduit at its best is a dirty place, and that iron and steel will rust, and when rusted may refuse to work.

Over a year ago I became engaged in some attempts to solve the problem at Coney Island. This system was not a sudden idea, but it has been a gradual development. For nearly two years it has been being gotten into shape, and a number of inventors have contributed their share toward its completion and success. To make an all-the-year-round system was our object. I assert with the utmost confidence that we have succeeded. To have gone over the same old ground, in the same old way, would have been folly for any one knowing of previous attempts and failures. Perfect insulation, no live wires in the conduit, fewest possible working parts, with nothing to get out of order! We have not attempted to make a road operative in fine weather and under ideal conditions, but have kept in mind that to insure success we must take the streets as we find them.

A conduit is used, similar to that of cable roads, but nothing like so large or expensive. With our improved shoe, a conduit two or three inches wide and seven inches deep will answer perfectly. In the slot of the conduit, attached to the car, runs a shoe extending nearly the length of the car. Fig. 8 shows the shoe detached from the car. The upwardly projecting pieces are the guides for making the shoe follow the conduit and conform to the curves. The shoe is so supported that should the car leave the track it detaches itself immediately and remains on the top of the conduit. It cannot get caught, as the cable grip sometimes does, and drag the car along through crowded streets at a dangerous speed. As seen in the illustration, the shoe is somewhat like a cigar in shape, so as not to give any sharp blow to the contact arms. The sides of the shoe are formed of conducting material, insulated from each other, and perfectly flexible, so as to follow any curves. In the conduit are placed two insulated cables, a metallic return being used. This I regard as necessary to ensure perfectly safe working. These cables run into and through contact boxes placed at intervals of ten feet on each side, they being arranged diagonally opposite, so that the distance between the boxes is about five feet. The construction of the boxes and the functions of their various parts will be readily understood from the illustrations. One shows the box closed and the cable running into the box ; the other, the box opened and the method of securing contact with the cable (Figs. 9 and 10).

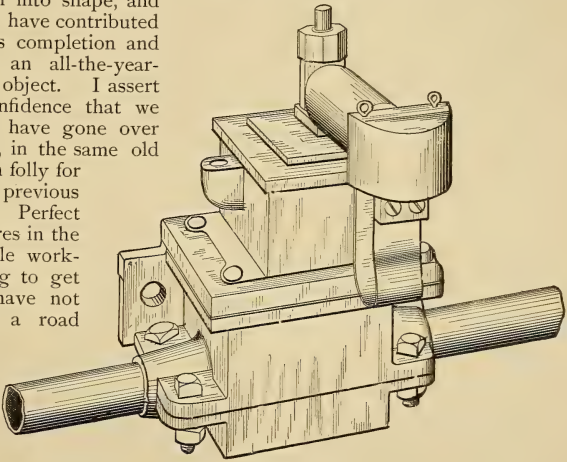


FIG. 9.—THE BOX CLOSED.

The main is carried into the box and, as can be seen, the lead and insulation are removed for about two inches. On this bared cable there is placed a brass clamp with two upwardly projecting tongues. The contact making portions of the device is a vertical rod, having at its upper end an arm projecting into the conduit, and at its lower end a brush adapted to be brought into contact with the tongues attached to the cable. The rod and its bearings must, of course, be properly insulated from the central box. When no car is passing, the brush is out of all electrical connection with the current conductor, but when the shoe on the car reaches the arm projecting into the conduit, it swings it to one side, bringing the brush on the rod into contact with the tongues fastened to the conductor, and the current passes to the motor on the car. As soon as the shoe on the car has passed the box, a torsion spring forces the rod back into its normal position, and that box is dead. The box is filled, as far as it can be without interfering with the movement of the brush, with solid paraffine and above that with "transil oil." This makes excellent insulation. Of course the spindle, which at times becomes "alive," and its bearings are thoroughly insulated from all parts of the box and cable. No accident to persons or animals appears possible with this system. To avoid sparking within the box, the ends of the shoe are made of insulating material, thereby establishing mechanical contact within the box before the metallic portion comes into contact with the arm, and also holding the inside contact after the current ceases to flow to the motor. Without such an arrangement the brushes would soon burn out, the oil become carbonized and the boxes useless.

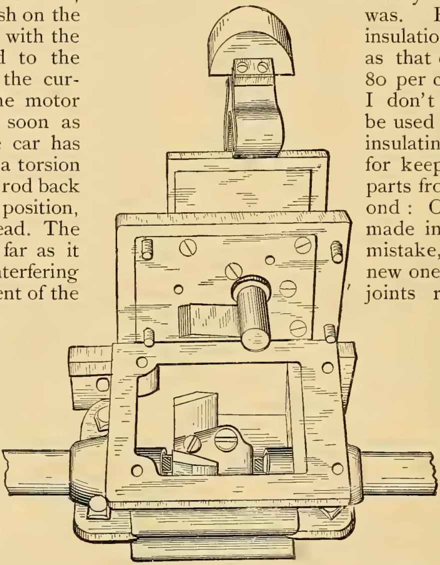


FIG. 10.—THE BOX OPENED.

Thus far I have described the box used at Coney Island, but we have several forms of box, entirely obviating the defects in the first. The number of working parts has been reduced, and we now have the device brought down to its lowest terms. But patents have not been obtained on some improvements and on others not yet applied for.

I will enumerate the best features and defects of the old box. First: Its insulation was excellent, that is, the theory of its insulation was. But the best oil insulation is not so good as that of air containing 80 per cent. of moisture. I don't think oil should be used on account of its insulating properties, but for keeping the working parts from rusting. Second: Our old box was made in several parts (a mistake, remedied in our new one-piece box); the joints required planing, an expensive operation. Paraffine oil is difficult stuff to hold, going through almost everything. In the joints we used oil paper, screwed them together as tightly as possible, but the oil softened the paper and the boxes leaked. This we remedied by painting the joints with "Insulac," which withstood the oil excellently. Third: Our stuffing box was a crude device, and did not, in many cases, keep out the water; but this is a simple mechanical affair remedied in our new boxes. Fourth: A torsion spring is not so good as a straight one, nor so reliable in its action. Fifth: We had a short brush in our box, when a long one should be used. Flexibility and sure contact are thereby secured. Sixth: It was a mistake to have the two upwardly projecting tongues ; one contact is the thing, and the brush always resting against it when the shoe touches the arm. Otherwise there will be a break on reversing and consequent "frilling" of the brushes, with carbonization of the oil. Seventh : To make an oil-tight joint between the cable and the box was almost an impossibility. We taped the cable where it entered the box, but when it was tightened up there was often contact between the lead covering and the box. Eighth : The box is too large. Ninth : Great care must be used in selecting and laying the cable. A slight defect gives leakage ; this decomposes the alkaline earths ; chlorine and caustic soda are perhaps produced, and the cable eaten away. Every joint must be carefully made and carefully sealed. Some one may say that it is impossible, but I answer that it is the duty of the supervising engineer to see that it is properly done.

I believe that our system has solved the question of conduit traction. To sum up, the objects of such a system are :

To remove from the streets of our cities and large towns the unsightly structure that our trolley construction demands ; to dispel all chance of injury to persons and animals ; to present no such lightning conductor as the trolley line ; to offer no obstacle to the work of the firemen, in case of a conflagration ; to remove all risks of fires being set by the electric current ; to avoid corroding action on water and gas pipes, and the iron foundations of buildings ; finally, to furnish all the advantages of electric traction without any of the present attendant evils.

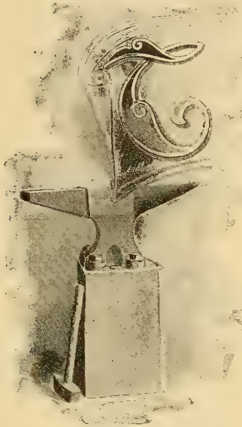
LEADING AMERICAN ENGINEERS.—DANIEL ASHWORTH.

THE result of close application and studious devotion to work is well exemplified in the case of Daniel Ashworth, who occupies a prominent position in the engineering profession, practicing as consulting mechanical engineer at Pittsburgh, and numbering among his clients some of the largest and best known industrial establishments in the United States—the Carnegie Steel Company, Ld., for example. Commencing work of a practical character at an early period, Mr. Ashworth passed through all the grades of shop practice. For a number of years he was master mechanic and designer for several prominent glass works in the United States, and during this time he became enthusiastically interested in the investigation of problems connected with steam engines and motive power generally. With the practical experience already acquired, he entered the new field well prepared to succeed, and his career has amply demonstrated how much may be accomplished by perseverance in a chosen line of work, coupled with natural inclination to the problems connected with it. With the outbreak of the Civil War he was found among the first at the front and participated in some of the heaviest engagements of the Army of the Potomac. Subsequently he was transferred to the engineers' corps of the United States Navy, in which he served until the close of the great struggle.

Mr. Ashworth is an active member of various scientific bodies, notably of the American Society of Mechanical Engineers, and of the Engineers' Society of Western Pennsylvania. He is also an honorary member of the Society of Stationary Engineers.

A MECHANICAL ENGINEER'S IMPRESSIONS AT THE WORLD'S FAIR.*

By George M. Dickie, M. Am. Soc. M. E.



THE one thing that impressed me most during the meetings of the marine engineering section of the great International Engineering Congress at the World's Fair was the way in which the subjects treated of in the various papers would broaden out and assume dimensions under discussion far beyond the scope of the original paper. The ideas expressed in a paper produced in a British seaport, when discussed by a marine engineer or shipbuilder whose experience was limited to the practice on the Great Lakes or rivers of North America, had to meet conditions and be compared with results that were not only new, but in many cases very startling to the author.

One day during the discussion of a paper on river steamboat practice, I was endeavoring to point out the advantage of compounding stern-wheel engines, recommending tandem compounds on each side, either condensing or non-condensing, when the author of the paper remarked that first cost was the most important consideration in the construction of a western river steamboat, efficiency or durability being of secondary importance. "But," said I, "the everyday expense of running must be an important matter, especially where transportation was effected so cheaply." "Why," said he, "I am afraid that the gentleman from the Pacific Coast has had but a small experience with Western river practice. As an example of economy let me give you an instance of a freight sternwheeler in my district that made her daily runs for the last season of eight months on a total expense of $2.25 for fuel, and this expense was caused by the carelessness of the crew one night in not securing wood enough for the next day's run, necessitating the captain's buying enough to last until dark, as his method of taking on fuel would not work in daylight. In this case what would be the advantage of compounding?" We had not considered the subject from this standpoint, and had to admit that such conditions would not justify more expensive engines to save fuel.

The steam engine exhibits at Chicago confirmed an impression that for years has been forming in my mind, that the prime mover which has done so much for the advance of civilization and material wealth is not now held in the same veneration as in years gone by. Designers, builders and owners now treat the steam engine no better than they would a lathe, a planing machine, a loom, or a printing press. Democratic ideas at present prevail in mechanics; the declaration has gone forth that all machines are equal, and by right are free to perform their functions with the least possible expenditure of material carefully disposed in the direct lines of strain, no matter how offensive these unclothed skeletons may be to those who remember the time when the steam engine was the master machine, had a splendid house or palace for its own use, had a dignity of its own, apart from, and above, the factory to which it imparted life and motion, and when its owner died or gave up business the great engine went as part of the land and buildings, and not as a mere manufacturer's implement.

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*From a paper read before the Technical Society of the Pacific Coast.

I looked in vain for some trace of the dignity of form and proportion and the grace of motion that characterized the factory engine of twenty years ago, the massive, finely molded base, the correctly proportioned columns and rich entablature, with the cylinder or cylinders so incased in polished mahogany as to be in harmony with the other statical parts of the structure, and all this, filled in with the artistic tracery of parallel motion and connections, making a complete machine that gave satisfaction to the soul of a true mechanic. With what is modern mechanical science, hampered by the all prevailing desire for something cheap to serve a present purpose, replacing these stately monuments of mechanical genius?

Here is what I found as the modern development of mechanical science. A square box, called the high pressure cylinder, close behind it a larger square box, called the low pressure cylinder, and usually a round box on top with a leg in each of the other boxes, called the receiver. Between these boxes, and the shaft journal, in the line of tension, and compression strains, either steel rods or straight castings are fitted of just such form and dimensions as will resist the strains produced when the thing works.

These lines may be perfectly correct and just the proper amount of material may be disposed around them, but I claim this to be an indecent exposure of the design. The disgusting nudity of these miserable machines was not the nude in art as we found it in the Art Building, but rather the naked skeletons of the anthropological exhibit. This setting up of the bones of a design as a finished result, denoting the presence of science without art in mechanics, produced on me a most painful impression, which deepened into actual shame that our profession had made such an unworthy exhibition of its own decadence. I am often told that the useful only should be retained in any design. That is true, but who can say what is useful? Your best poet says,

"Nothing useless is or low,
  Each thing in its place is best;
And what seems but idle show
  Strengthens and supports the rest."

What would the beautiful building be that shelters these miserable mechanical skeletons without its clothing of staff? What hideous specters would have surrounded the Court of Honor if only the actually useful had been allowed a place? In regard to our other surroundings, we are not satisfied with the bare necessities of existence, and why should we be so in mechanics? One of the conditions resulting from this utilitarianism is the sameness of design by all makers of certain types of engines. They could only be identified by the name plates and were entirely without character, and are to mechanical art what a chromo is to a painting.

This condition is very distressing when we come to follow these mechanical contrivances to the permanent positions they are to occupy in factories or power stations throughout the country. I must say, however, that in the various Eastern power stations that I visited the engine designs as a rule were far more satisfactory than those exhibited at Chicago. In giving you the general impressions produced on my mind by the steam engines exhibited, I must make one or two exceptions, notably a set of vertical engines for driving electric generators, exhibited by a German firm, the satisfactory proportions of which did much to relieve the distress produced by the American horizontals. It seems to me that the modern idea as to form in mechanics is limited to what a planing machine can produce in flats and a self-acting slide rest lathe can produce in rounds.

Before leaving the matter of engine design as displayed in the exhibits at Chicago, I desire to call attention to the prevailing indifference manifested by engine builders and those who employ them as to whether their designs are in keeping with their surroundings. While East I visited a great many power stations, and in no case could I trace any relationship between the engines and the structures that sheltered them; in fact, as a rule, the designs were entirely opposed to each other. In one city I found a very pretty Gothic building sheltering a very ordinary horizontal pumping engine. The house was a thing of beauty, displaying true artistic skill in its design. The machine it sheltered was—well, I hope for the sake of my profession that it was bought in some machine junk shop, and not designed for the place it occupies.

In another city I was driven to the water-works, and on seeing the buildings my hopes ran high, expecting for this once I would find that a master had been there. The engine house was a castellated structure of rough-hewn stone in the baronial style, the water tower being incased in the same style of stone work with a castellated top like the engine house, and the bronze railings and gates, with their battleaxe terminals, were all in keeping with each other. But with the architect all this unity of design ceased. Within, I found two beam pumping engines, very well designed in themselves, but it just occurred to me that the owner of this Norman castle had gone down to Greece and stolen the engines out of some Ionic temple. Another set of engines in the same building were of the horizontal fly-wheel type, without any character whatever. Evidently the first two sets of engines were special designs, and if the designer knew where they were going, and in what kind of a structure they were to pass their lives, why did he not design them so that they would be at home there? What a splendid opportunity to mount a beam on a Norman tower, supported on a rough hewn base, with loop holes for the foundation bolts! The horizontal things had no business there at all, and as they were new, they only served to show how far we have fallen away from all appreciation of what is good in design.

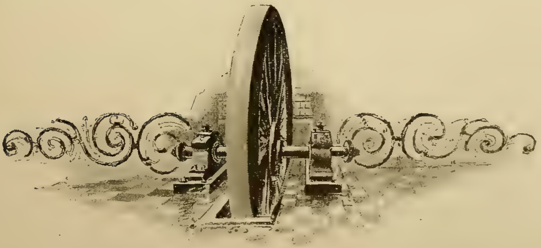
RELATIVE ENGINE AND DYNAMO CAPACITIES.

By O. T. Crosby, Assoc. M. Am. Inst. El. Engineers.

SPEAKING of the proper proportion between the capacity of an engine and that of a dynamo, at a recent meeting of the American Street Railway Association, the author maintained that, according to the best practice, an engine should be at least no greater in capacity than the dynamo to which it is attached. The engine will certainly not do its work as economically if it be run ordinarily at a considerably lower output than the output for which it has been calculated as a normal output. The dynamo does not suffer by any means so badly in thus being brought below its rated work.

If, therefore, an engine of 600 horse-power be attached to a dynamo of 500 horse-power, the man running the station will ordinarily, and very properly, limit the load which is thrown on the couple—since they now constitute a couple—below the capacity, as he understands it, of the dynamo, rather than of the engine. He will endeavor to keep within safe limits, with respect to his dynamo. In thus keeping within safe limits with respect to his dynamo he is keeping too far under the limit with respect to the engine for economical work. The dynamo is not what one should have unless it can be run at its rated load without any injury. If at the same time the engine is run at about its rated load, perfectly satisfactory results are being obtained in both cases as to repair, and the best results in both cases as to the efficiency of output, and that is probably the largest question involved in the whole matter. I have had some conversation with engineers, and I find that this opinion is becoming quite well fixed—that the generator and engine should be at least equal, with some in favor of having an engine slightly lower in rated capacity than the dynamo. I am told by the representative of a large firm of engine makers that most of the complaints received from their customers are due to the fact that they were running the engines below their proper load.

There is another point, as between vertical and horizontal engines. There is no difference in the machines, intrinsically, as to their value. You can make a splendid vertical engine, and you can make a splendid horizontal engine. It is impossible to speak on these subjects with as much definitiveness and emphasis as many would like. A vertical engine, as compared with a horizontal engine, involves a difference in the space occupied, and space represents money investment, and there, in my opinion, is the meat of the whole question. There is enough experience in the engineering practice to justify us in feeling that vertical engines and horizontal engines are almost equal in value as driving power. Speaking for the electric side, it is a matter of indifference to the generator how it is driven. One should consider in the most careful way the cost of all these elements in a plant—the engine complete, with all its appurtenances, and the space occupied, and the economy of its operation. If the question be approached in the broadest way, one may be led to the use of a vertical engine on real estate considerations more than any other. I believe that the real estate consideration, the price per square foot of building, is the determining element in large plants, as to which of the two types it is best to use. It is largely the same question which usually determines between the condensing and the non-condensing engine. The condensing process saves coal, but may cost just so much extra investment. I heard it stated the other day by a competent engineer that the condensing process, when coal is in the neighborhood of three dollars a ton, may justify an investment of $100 per horse-power to bring it about. The analogy between the cases of condensing and non-condensing engines and between vertical and horizontal engines is very close. One can get an excellent plant either way.



WASTE ENERGY.

By George Hill, M. Am. Soc. M. E.

THE amount of energy which is constantly being given off without doing any measurable, useful work may justly be said to be far beyond all conception. Even if we limit the field to the so-called wastes which occur in one city, measuring simply those of which we have knowledge, the total expressed in figures would be something astonishing. But leaving broad generalizations, leaving the question of utilizing the heat of the sun's rays, or recovering useful work from the potential energy stored up by the tons of water that the fleecy clouds carry through the air, or in the tides ever ebbing and flowing, or in the waves of the ocean, could we harness any of them, let us see what it costs to use present appliances under ordinary conditions.

In order to be able to express results in intelligible form, let us assume the case of a fifteen-story office building, 50 by 100 feet, standing on the corner of a street, the stories being all above the street level, and the basement being devoted to the power plant. The entire building and its plant would be designed in accordance with the best modern practice, with electric light, hydraulic elevators, exhaust steam for heating, etc.

The mechanical work required to be performed in a building may be said in a general way to be lighting and heating it, and to elevate its occupants to the points to which they desire to go, and also to lower them from these points. The amount of work actually required to be performed is, first, an expenditure of a certain number of foot-pounds of work for heating, which may be most readily expressed in tons of coal. We would have to make good losses by radiation through walls, windows, floors, roofs, etc., and would have to warm the entering air required for ventilation. For the purpose of the present case it may be assumed that all this would require, say, 85 tons of coal a year, or 2,125,000,000 heat units. Taking the year round, there would be required for the lighting of such a building as is here in mind, about 1,000,000 lamp hours, this assumption being based on a lighting capacity of each lamp equivalent to 16 candles. This, converted into coal, on the assumption that each pound contains 12,500 heat units, and that one candle-power is equivalent to 0.0688 heat units per hour for 100 per cent. efficiency, based on data obtained from the arc light, gives the number of tons as 0.044. For elevating the requirements are, of course, zero, since if we had an elevator of perfect efficiency, and a method of storage of perfect efficiency, we could, as soon as we had stored up enough energy to do one day's work, go on forever, the energy expended in elevating people being stored up again when they are lowered, and the energy required to start the car at the landings being made up by the energy given out when it was stopped. From this it will be seen that if we had machines of perfect efficiency, we should be able to perform all of the mechanical services of one of our large buildings with an expenditure of 85.044 tons of coal.

To determine what the wastes would be in this building we must convert the potential energy stored up in the coal into useful work. Various methods have been proposed of accomplishing this, but the limitations imposed by cost, convenience of manipulation, usage, etc., all point toward the steam engine. I would not be considered as in any way decrying the vast amount of human ingenuity which has been expended thereon, but I cannot but feel that it is very unfortunate that our development should have taken place in utilizing the expansive force of steam rather than in some other way, as will be hereafter noted. In the first place, the present use of coal involves a loss at the outset, due to waste in the mine, waste in its preparation for the market, waste in transmission and waste in useless combustion, these combined wastes amounting to probably two pounds of coal for each pound used.

Taking the steam engine in its most efficient form, we would have, where it is non-condensing, between the limits of 14.7 and 300 pounds pressure absolute, an efficiency of about 23.4 per cent., this being found by dividing the difference between the absolute initial and final temperatures due to the pressures assumed, by the absolute initial temperature. If we take the practical limits of 120 pounds of initial pressure and 5 pounds back pressure, we would have an efficiency of 15 per cent., which corresponds to a consumption of coal of 1.33 pounds per horse-power per hour, and it is on this basis that we must calculate the generation of all power required for our electric lighting.

At the present state of efficiency of the art of electric lighting, we can, as a practical thing, obtain about twelve 16 candle power electric lamps for each horse-power. This would make necessary the generation of 85,000 horse-power hours annually. Should we attempt to gain so high an efficiency, as above noted, we would have to run the engines constantly, and therefore often very much underloaded, since the lighting duty varies constantly, both during each hour and during the day, with a consequent high friction loss. If, on the other hand, we adopt a proper subdivision of engine capacity, we should have a lower efficiency, so that it will be but fair to assume that, adding the inevitable losses in the piping, in the cylinder of a good engine, etc., we would have 170,000 horse-power hours as the amount of work required to be performed, which means the annual consumption of at least 113.5 tons of coal. Subtracting the net number of tons heretofore given for lighting from the above, and also subtracting the 85 tons required for heating, leaves a net waste of 28.5 tons. It might be said that gas could be more effectually used as an illuminant than electricity, which might be true, were it not that with gas at any price that you please per thousand, 20 feet will give but 80 candles if burned as an illuminant, while the same number of feet will give 160 candles if burned in the cylinder of a gas engine used for driving an electric generator, as an average for every-day practice.

These facts are sufficiently discouraging, but the worst of all is yet to be faced. When we come to elevating we find, usually, the hydraulic machine employed. This machine is simply an hydraulic cylinder with a piston working in it, which carries on the end of its rod one or more multiplying sheaves, over which the hoisting rope passes. Water under pressure is admitted on one side of the piston only, to elevate the car, which, by gravity, discharges this water on its down trip. It will be seen, therefore, that the number of trips made per day determines the amount of water consumed, quite regardless of the amount of energy required. The elevator cars are sometimes made of 1500 pounds capacity, and range from that to 2500 pounds, and are counterweighted within about 500 pounds, so that we should have about 2000 pounds as the load. If the car runs at a speed of 450 feet per minute, and runs but one-third of the time, it would have an average speed of 150 feet per minute, and since it elevates only one-half of the time, the average speed throughout the entire day would be equivalent to 75 feet per minute, and since, further, there are in an office day, roughly, 500 minutes, we would have a total travel of 37,500 feet. This, multiplied by four, for the number of cars, and 2000 pounds for the load lifted, the amount of water required to fill the cylinder being always the same, regardless of the load, gives a total of 300,000,000 foot-pounds per day.

If we assume that the pumps which are employed convert the energy in the coal into work at about the rate of 25,000,000 foot-pounds per 100 pounds of coal, which is an efficiency of about 2.6 per cent., we would require, to do the work, an expenditure of 1200 horse-power each day, and since there are 293 office days, this would mean 175.8 tons which are a total waste. In addition to this, we have the knowledge that a plant, said to be economical, takes double this amount of coal under the same conditions. Our bill would now stand as follows:

Coal required at building......		289.3 tons
Coal wasted in mining, etc., to deliver this amount at the building....................		578.6 "
Total consumption of fuel..		867.9 "
Useful work expended in tons		
Lighting..............	0.044	
Heating..............	85.000	85.044
Loss......................		782.856

It is highly probable that the average losses are double this, and in many cases treble. This is truly a state of affairs of which engineers cannot be proud. The water-wheel has an efficiency of something like 90 per cent., while the best that man can do when he comes to convert the energy stored up in the coal to his own comfort is about 10 per cent. These losses might perhaps be reduced in a variety of ways. We know, for example, that it is entirely feasible to obtain an efficiency with water-wheels and generators of about 80 per cent., and we could convert the energy stored up in the electric current into heat with an efficiency of about 90 per cent., and into light with an efficiency of about 20 per cent.; or we could convert the coal at the mines into gas with an efficiency of about 80 per cent., which could be converted into energy with an efficiency of about 25 per cent.; the latter could, in turn, be converted into electricity with an efficiency of about 80 per cent., from which we could go on; or we might use gasoline, natural gas, or some other form of liquid fuel with an efficiency of about 25 per cent.

We might even pulverize the coal, and by mixing it with air, produce an explosive compound, which introduced into the cylinder of an engine, would give an efficiency of about 25 per cent., but all of these figures are far below those that we should attain. If, instead of steam, we had used some other form of expansive gas, we might have reached a somewhat higher efficiency still; but for all of them there is a more or less insurmountable obstacle presented by practical conditions.

We owe a great deal, beyond any doubt, to steam, but we have reached the point where we should be able to see that steam is not the panacea for all ills. Somewhere, lurking in some man's brain, there must be the rudiments of the idea that will enable us to convert effectually the stored-up energy in coal into the useful energy of the electric current. It is certain that we must come to this eventually. Take the requirements of our office building! Every man wants his office heated a little differently. No form of apparatus that can be devised that is practical will accomplish this. The electric current does it perfectly, but unfortunately, it costs too much. The incandescent lamp is much the most efficient form of illumination which we at present possess for the lighting of small spaces. Ten times more efficient is the arc lamp, but we have not yet progressed far enough on the road to subdivide it sufficiently to satisfactorily adapt it to domestic and office building lighting.

The electric elevator is now far more efficient than the hydraulic, requiring the expenditure of only about one-fourth of the number of foot-pounds, and about one-tenth of the coal, but it is still inefficient, in that we have no means of overcoming the waste caused by lowering people under the brake, when their weight exceeds that of the counterweight. In electricity, transmissions of over 20 miles have been made with a total efficiency of over 50 per cent., which is about ten times better than with steam, but it is much to be feared that this generation will have to be content with a comparatively wasteful form of converting energy, while fully realizing that just beyond its grasp lies one most perfect.

Do not let the fact that we are required to use the steam engine, and therefore, as its friends say, with a self-satisfied smirk, "We come back to it after all," blind us to the true condition of affairs, but rather let us hope that the day is fast approaching when it will take its true place as a scientific curiosity, illustrative of the unfortunate effects which follow from making a wrong start, the day that shall find us availing ourselves of the multitudinous forces provided on all sides by an all-wise Creator, with an efficiency equal to that already attained in the water-wheel.

Current Topics.

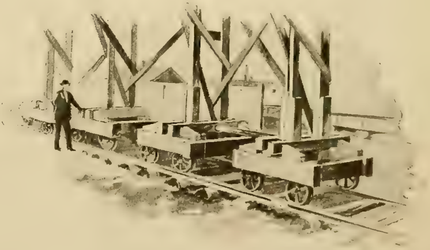
Power from the burning of city garbage is a subject of rather alluring aspect which latterly has commanded not a little attention, particularly in England, where special efforts appear to have been made to arrive at an understanding of its true status. How to dispose of the garbage accumulations from any restricted area holding a comparatively large number of people, in a simple, rapid, and economical manner has always been a problem of importance to municipal authorities, and now that it has been proposed to burn the stuff and to utilize the heat for steam raising, thus actually making the disposal of the wastes a source of profit, a field of inquiry has been opened up from which interesting developments may be expected. Burning garbage as a means to get rid of it is by no means a new thing. Garbage destructors have been known and tried for many years, more or less successfully, but the utilization of the heat of combustion carried on in them is of comparatively recent origin and what has thus far been done in this line has been of a purely experimental character, leaving much yet to be determined as to the practicability of the scheme. According to several reports, however, one English municipality, the town of Harrogate, has decided to give it a thoroughly practical trial, under everyday conditions, having determined to light a certain defined area in the town by electricity, the current to be produced by dynamos driven from engines which are to receive their steam supply from boilers heated by the burning of the town refuse. It has been figured out in a very plausible way that the plan will yield a profit to the town of several thousand dollars a year, and it now remains to be seen what actually can be accomplished. One fact which should be kept prominently in view in every proposed undertaking of this kind, but which does not seem to receive its due share of attention, is that by using only city refuse as fuel, there will, in all likelihood, be intermittence of operation, since the supply of the fuel will, most probably, be intermittent, and if other fuel must and will be used to bridge over the intervals, the final summing up will be subject to important modifications.

THE use of town refuse as a steam-raising fuel has more recently been referred to by Professor Unwin in his much-quoted lecture on "The Development and Transmission of Power from Central Stations," delivered before the Society of Arts of Great Britain. In this he mentioned more particularly what had been done in an experimental way at Leeds and at Oldham, where steam boilers were interposed between the garbage furnaces and the chimneys, combustion being promoted by using steam jets. In the trials at Oldham, six destructor cells were used, burning one and one-half tons of refuse per hour. The gases passed through a multitubular boiler, and the feed was measured by a meter. The temperature of the gases was 2019 degrees before reaching the boiler, and 900 degrees after leaving it. Thus only about two-thirds of the available temperature range was utilized In two trials the mean evaporation was found to be 2780 pounds of water per hour. Deducting 1500 pounds of steam used for the steam jets, there was a surplus evaporation of 1280 pounds per hour, or between forty and fifty horse-power of energy from the six cells. If a boiler with larger heating surface had been used, possibly an evaporation one-third greater would have been obtained, or, say, 3700 pounds per hour. Again deducting 1500 pounds used in the steam jets, there would be a surplus or available steam supply of 2200 pounds per hour, or, say, eighty-eight horse-power from the six cells. This gives about forty pounds of refuse per effective horse-power hour. Professor Unwin, however, also pointed out as the chief difficulty in using the available energy of the destructors the circumstance that the refuse must be burned at a regular and almost uniform rate, while the demands for power for most purposes are varying demands. There would appear, therefore, to be still an important gap to be filled in solving the problem of employing the material as a useful fuel before much success can be expected to attend the method.

THAT boiler chimney shafts have a movement of their own, due to expansion and contraction under the influence of hot furnace gases, and that they should not be rigidly attached to the walls of any important building because of the consequent risk of cracking walls is well enough known. The fact that such movement takes place is generally duly taken into account in putting up a substantial structure of any great magnitude, and where it is overlooked, ocular demonstration of its existence soon unpleasantly presents itself. To what degree the movement amounts, however, even approximately, has always been a matter of mere speculation. It is all the more interesting, therefore, to note a recently published paragraph referring to the case of a chimney, in providing which with a casing of ornamental brickwork opportunity was given for observing pretty nearly how great the expansion and contraction were. The observations which were made seemed to show that for a 100-foot stack, heated from the temperature of the atmosphere to that of the gases passing through it, an elongation of nearly one inch would occur, thus giving a fairly definite measure of what might be expected in other similar cases.

Not the erection alone, but the transportation as well from one place to another, of large buildings is one of the arts which has been developed to a relatively high degree, and the building contractor of to-day would probably have little hesitation in offering to move anything anywhere. Several years ago the successful shifting of an entire row of large brick and stone houses to accommodate a change of street line in one of the large cities of the United States evoked general astonishment and admiration, and since then similar operations, both larger and smaller in proportion, have been carried out in a number of places. The latest one of the kind, described a short time ago in Le Génie Civil, was the removal at Rouen, in France, of a large timber and iron shed, 164 feet long, with a 97 foot span, over a distance of several hundred feet. The structure was made up of twelve trusses, supported on double posts at each end, and the total load to be shifted amounted to about 180 tons. The crucial part of the undertaking was in the lifting of the twenty-four supporting posts at one and the same time, and it was indispensable also that this raising should be accomplished in a manner which would not in the least degree alter the relative positions of the posts. One circumstance largely favoring the undertaking was that the slope of the ground over which the shed had to be moved was slight and that the posts when in their new position would require raising to the extent of only about 10 inches. The mechanical appliances necessary, therefore, were comparatively simple, comprising only some winches, cables, and screw jacks, some strong blocks and the special trucks which had to be built to carry the posts in transit. Rails and sleepers, necessary to complete the outfit, did not add greatly to the expense. The first operation consisted in laying a track underneath each line of posts and then building around each post a truck on to which, subsequently, the posts were lifted. As soon as all the trucks had received their loads, they were coupled together by iron rods so as to transmit the traction in the line of the posts and also to preserve the proper distance between them. Somewhat beyond the far end of the distance to be traversed two piles were driven into the ground almost in line with the two rows of posts, and at each side of these piles another and smaller one was driven, to serve as the fixed points for the cables used in hauling. The latter, starting from these, passed successively around pulley blocks on the two heavier piles, then around blocks fixed to the leading trucks, and finally were wound on a winch, placed inside of the building. A graduated plank was laid down along the whole length of the route to aid in securing uniformity of progression in all the trucks, and the whole operation was carried out expeditiously and successfully.

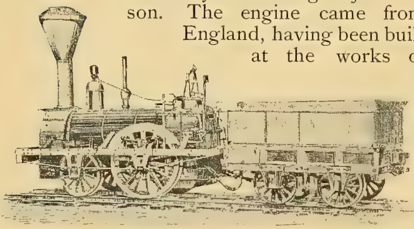
MOVING A LARGE SHED.



METHOD OF MOUNTING SUPPORTING POSTS ON TRUCKS.

April 189 4

As illustrations of the improvements made in locomotives during the past half century, the State Railroad Commissioners of Maine in their recently issued report for the year 1893 present two suggestive engravings, one of them showing the first locomotive used in the State, and the other, one of the modern engines now running on the Maine Central Railroad. The first one is here reproduced, and supplies a decidedly interesting object lesson. The engine came from England, having been built at the works of Robert Stephenson & Co., in the year 1835, and made its first trip over the Bangor, Oldtown and Milford Railroad on August 19, 1837. This road was then generally known as the "Veazie road," and the track was made of wooden rails, strapped with iron. The shackles used to connect the engine and cars were made of three thicknesses of sole or belt leather, held together by copper rivets, and had a hole in each end so as to hook over an upright stationary pin, bolted or driven into a rigid beam extending from the end of the car. The exact weight of the engine is not known, but it probably did not exceed 25,000 pounds and its power was correspondingly feeble compared with that of modern locomotives. It is said that, for a time, the engine was run in opposition to a six-ox team employed by a Bangor lumber dealer, who was not willing to pay the rates charged on the railroad, and it was not until the management of the line came to what he considered fair charges that he turned his traffic over to it. With the developments made since then in the whole railroad field, in the business as well as in the engineering departments, scraps, like these, of early railroad days make interesting reading.

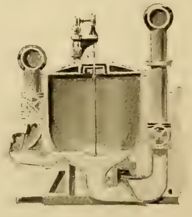


THE FIRST LOCOMOTIVE IN MAINE, 1836.

So much has been said and written for many years about heavy armor-plates of iron, steel and composite structure, especially in connection with naval developments, that the more modest means of inert defense in military operations have, to a great extent, dropped out of sight. High-power guns, capable of hurling ponderous masses of metal through almost incredibly large distances with most destructive results, have created the impression, and not without some reason, that nothing but metal barriers can withstand their effects, and earthworks and masonry structures, once potent factors in warfare, have almost entirely lost their significance. Still, antiquated though they may be, their usefulness, in some respects, remains undiminished to this day, and military authorities yet look to them as possibly most likely and valuable means of protection against an enemy's fire. Even snow banks, the small boy's armor in mimic warfare, have been found to answer a practically useful purpose in the actual, deadly business of war and promise to become looked upon as by no means despicable intrenchments in these times of much-developed death-dealing instruments.

It may not be uninteresting under the circumstances to resurrect a few particulars of what has been accomplished with such "snow armor" in recent years, a series of official tests of its virtues for breastworks having been made in Norway not long ago with results of a most suggestive kind. The breastwork which had been built for the purpose was about 60 feet long, 5 feet high, 10 feet thick at the ground and sloped up to a thickness of about 6 feet at the top. It was made by the soldiers rolling large snowballs, putting them in a row, and then filling in the spaces with snow, packed tight by means of shovels, swords, and bayonets. Shots were then fired at the bank from the regular army rifle at a distance of about 180 feet. Seven shots at the upper portion, about 12 inches below the top, went clean through; three, aimed somewhat further down, remained in the snow and were afterward dug out. One of them penetrated to a depth of about 4 feet, and the other two to slightly less depths. The snow was quite free from fragments of ice, but the projectiles were all found to be flattened and broadened toward the front. At the time of the trials the thermometer stood slightly above the freezing point. Water was then poured over the breastwork so that on the next day it had a coating of ice. Ten further shots were then fired at a distance of about 330 feet with results contrasting remarkably with those of the day before. The snow wall was easily penetrated and the shapes of the projectiles were not altered. Seven of them went completely through where the intrenchment was about 6½ feet thick and could not be found afterward. Of the other three projectiles, two were found at a distance of about 26 feet behind the breastwork, and one immediately behind it. Evidently the mass of snow had become more porous after the water bath; hence, its diminished resisting power. The conclusions to be drawn from these trials could not be otherwise than of a most favorable character, and it is not strange, therefore, that the snow breastworks should have called forth rather enthusiastic commendation from those who had the tests under supervision. That they performed so well is, indeed, noteworthy.

Pump modifications have, in the lapse of years, been made almost without end, bridging, in an interesting manner, the gap between the simple water raising machines of the old Egyptians and the high duty pumping engines for city water supply of the present time. Some of them, indeed, have been little used and less known pieces of apparatus, noteworthy simply, perhaps, because of some ingenious peculiarity of mechanism; others again have become widely familiar, entering even into household service; still others, while having made for themselves a most important place in current engineering work, are well known only to those immediately concerned in their operations, though deserving of wider notice and more general appreciation. Not the least interesting of these is the ingenious appliance invented a number of years ago by Mr. Isaac Shone, an English engineer, and forming part of his now much-used system of sewerage, in which the sewage from the several districts into which a city is divided is collected at numerous small pumping stations, and is there automatically raised into one common discharge sewer, leading to one common outlet. The ejector pumps are operated by compressed air, generated at one central power station and distributed to the several pumping stations. The construction and operation of the ejectors will be readily understood from the accompanying illustration. The sewage, or other liquid to be pumped, gravitates through the inlet pipe at the left and gradually rises in the body of the apparatus until it reaches the under side of the bell at the top of the large chamber. The air at atmospheric pressure inside of this bell is thus confined and, as the liquid continues to rise around it, its buoyancy is sufficient to lift it together with its spindle and to open a compressed air admission valve at the top. The compressed air, thus automatically admitted into the ejector, presses on the surface of the liquid within the apparatus, driving the whole of the contents before it through the bell-mouthed opening at the bottom, and through the outlet pipe at the right to a higher level. The liquid can escape only through the outlet pipe men-



THE SHONE EJECTOR.

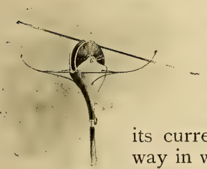
tioned, since the instant air pressure is admitted into the ejector case, the valve on the inlet pipe falls on its seat and prevents escape in that direction.

THE sewage passes out of the ejector until its level falls to such a point that the weight of the sewage retained in the cup in the lower part of the case, which is no longer supported, is sufficient to pull down the previously mentioned bell and spindle, thereby reversing the compressed air valve, which first cuts off the compressed air supply and then allows the air within the ejector to exhaust down to atmospheric pressure. The outlet valve then falls on its seat, retaining the liquid in the discharge pipe. Flow through the inlet then begins once more and the action thus goes on as long as there is any liquid to be pumped.

PARTICULARS which have been gathered of some of the leading cable street railroads in the United States, where cable traction is avowedly in more extensive and successful use than in any other country of the world, give, among other data, some interesting figures of power equipment per mile of road and per car run. Thus, it appears from statistics of eleven different lines, that the average practice has been to provide a fraction over one hundred horse-power for each mile of cable, one-half of this power being actually used to run the cable up to its proper speed with its load of cars, with somewhat of a surplus, and the other half constituting a reserve, to be brought into use in case of a breakdown. or in case of need of repairs. As to the horse-power required to haul a car, the available figures show a remarkably wide disparity between themselves, one and one-half horse-power being required to run a car at a certain speed in one city, while as much as nine horse-power appear to be necessary for a car at the same speed in another city. Of course, there is the question of grades to be considered, the lines in some of the places being nearly level, while in others there are grades of fifteen, sixteen and eighteen per cent. On the whole, however, the horse-power per car may be taken to have a pretty close relationship to the amount of business done on the various lines. It is interesting, further, to note that the universal size of cable now in use is one and one-quarter inches in diameter. The cables weigh two and one-half pounds per foot, and their maximum wear is about 60,000 miles in distance run.

IT is said of Henry Renwick, the great patent expert, who was the first examiner appointed in the Patent Office at Washington, and who resigned in 1854, that he did so because he had made up his mind that comparatively few more patents would be issued ; that the whole field of invention had been pretty thoroughly explored and exhausted, and that he, therefore, thought he ought to look out for some business of a more permanent kind. At the present day, with the multitude of inventions that have cropped up, and with the host that are yet to follow, this early view of the subject is uniquely interesting. Experience has more than borne out the statement once uttered, that one invention makes, at least, one additional one necessary. If an article be invented, a machine for making it must often be invented also ; the building of this machine may again necessitate the employment of some special tool, hitherto unnecessary, for which, too, we may have to depend on inventive genius, and in this way multiplication of devices may go on to an extent little imagined in the beginning. The discovery and manufacture of kerosene for illuminating purposes, for example, is said to have been alone responsible for about five thousand different inventions which have been patented. There are similarly said to be about three thousand separate inventions for coupling railroad cars, and something like eight hundred for knitting machines. Other equally striking cases would no doubt be afforded by a study of the Patent Office Gazette, but are scarcely necessary to complete the picture.

TROLLEY wheels of electric street cars, as many know, have the annoying tendency to leave the trolley wire, sometimes at the most inopportune moments, particularly at switches and at track crossings where the cars are subjected to perhaps more than ordinary jolting. Of course, when this happens the car becomes stalled and is helpless until the wheel is replaced by the conductor in charge. Under certain circumstances the delay thus occasioned may entail the most serious consequences and more or less interest has, therefore, always been attached to proposed means of restraining these aerial excursion tendencies of the wheel and of keeping it in more or less direct communication with its current supply wire. One way in which this has been accomplished on one of the Chicago street car lines is shown in the annexed illustration, representing projecting auxiliary conductors on each side of the trolley wheel, forming a pair of prongs, one of which must of necessity come in contact with the wire if the wheel slip. Each prong consists of three iron wires which are welded into one near the tips. The latter are somewhat flattened to prevent the trolley wire from sliding over the ends, and the distance between them is about 20 inches. Whether the trolley wheel be on or off the supply wire, electric connection between it and the car is uninterruptedly maintained by these prongs and their action would appear to be entirely satisfactory.



A NEW TROLLEY DEVICE.

WHAT is the normal relative demand for engineers in the United States? Considering the rapid growth in engineering schools, particularly those of mechanical engineering, during the past ten or fifteen years, this question is one of not a little interest, especially to the small army of young men who are availing themselves of the education which these schools afford. Some suggestive figures, directly bearing upon the subject, were given by Professor Samuel B. Christy in a paper presented before the International Engineering Congress, held at Chicago last summer, Professor Christy, on reference to the tenth census, up to 1880, having found the distribution of the wage-earning population of the United States at that period to be about as follows:

	Per Cent.
Agriculture	44.10
Professional and personal	23.43
Trade and transport	10.41
Manufacturers and mechanics	20.24
Mining and metallurgy	1.82
	100.00

Now, although some employment, Professor Christy remarked, is given to engineers by the first two classes of wage-earners, most of it comes from the last three classes, each of which is closely related to some one particular class of engineering work. Thus, the work of the mining engineer comes from the activity of those engaged in mining and metallurgy; that of the civil engineer chiefly from those engaged in trade and transport; that of the mechanical engineer from those engaged in manufactures and mechanics. The personnel of these industries, it is seen, were related numerically in the ratio of 1.82 : 10.41 : 20.24, or as 1 : 5.72 : 11.12. Hence it would seem, in a general way, as if the relative field for mining, civil, and mechanical engineers in 1880 was roughly in proportion to the numbers 1, 6, and 11. Now it was found that the number of graduates from the schools of mining, civil, and mechanical engineering, in 1880, were in the proportion of 1 : 4.25 : 1.11, and both civil and mechanical graduates, but especially the latter, were at that time much below their normal ratio.

Examining the ratios of graduates in 1892 from the schools of mining, civil, and mechanical engineering, Professor Christy found them greatly altered. They had become 1 : 7.73 : 9.27.

In short, then, unless the relative proportions of the wage-earning classes have become essentially changed in the last fourteen years since this census was taken, the supply of civil engineers had most nearly approached the limit of demand, and that of mechanical engineers was still somewhat below it. It appears to be evident, therefore, that the apparently abnormal growth of engineering schools in recent years has been, in reality, only a readjustment to make good an abnormal deficiency in the supply of mechanical engineers. It is interesting in connection with this to note that the rapid growth in engineering schools since 1880 corresponds almost exactly with the advent of electricity as a practically useful form of energy. While no one, as Professor Christy aptly stated, can safely predict the outcome in this direction, a reaction is not unlikely to ensue in the near future and many young men with great expectations may meet with disappointment.

It would seem quite unnecessary to make any special plea for the reprint elsewhere in this number of the greater part of Mr. Coxe's admirable account of how coal is sampled and tested at the extensive collieries at Drifton, in the Pennsylvania coal region, with which he is so prominently identified. Testing work which savors of the chemical laboratory is generally associated in the mind of the practical man with so much refinement in measuring, weighing and calculating, that he is not apt to give it very favorable thought, unless absolutely necessary, whatever the value might be of the results of such investigations. Mr. Coxe, however, shows that very useful coal analyses can be made by exceedingly simple means, and the testing outfit which he describes ought to readily commend itself to many large users of coal. It is a comparatively inexpensive affair, its use involves no particularly delicate manipulations, and the results to which it leads are exactly what the man who pays for the coal most wants to know.

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